

## Introduction to Artificial Intelligence in Finance and Quantitative Analysis

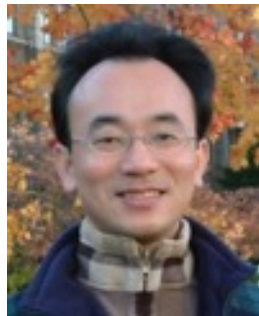
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MBA, IM, NTPU (M6132) (Fall 2022)

Tue 2, 3, 4 (9:10-12:00) (B8F40)



<https://meet.google.com/paj-zhji-mya>



Min-Yuh Day, Ph.D,  
Associate Professor

Institute of Information Management, National Taipei University

<https://web.ntpu.edu.tw/~myday>





# Min-Yuh Day, Ph.D.



2020 Cohort



**Associate Professor, Information Management, NTPU**

**Visiting Scholar, IIS, Academia Sinica**

**Ph.D., Information Management, NTU**

**Director, Intelligent Financial Innovation Technology, IFIT Lab, IM, NTPU**

**Artificial Intelligence, Financial Technology, Big Data Analytics,  
Data Mining and Text Mining, Electronic Commerce**



# Course Syllabus

## National Taipei University

### Academic Year 111, 1<sup>st</sup> Semester (Fall 2022)

- **Course Title: Artificial Intelligence in Finance and Quantitative Analysis**
- **Instructor: Min-Yuh Day**
- **Course Class: MBA, IM, NTPU (3 Credits, Elective)**
- **Details**
  - **In-Class and Distance Learning EMI Course (3 Credits, Elective, One Semester) (M6132)**
- **Time & Place: Tue, 2, 3, 4, (9:10-12:00) (B8F40)**
- **Google Meet: <https://meet.google.com/paj-zhhj-mya>**



<https://meet.google.com/paj-zhhj-mya>



# Course Objectives

- 1. Understand the fundamental concepts and research issues of Artificial Intelligence in Finance and Quantitative Analysis.**
- 2. Equip with Hands-on practices of Artificial Intelligence in Finance and Quantitative Analysis.**
- 3. Conduct information systems research in the context of Artificial Intelligence in Finance and Quantitative Analysis.**

# Course Outline

- This course introduces the **fundamental concepts, research issues, and hands-on practices of AI in Finance and Quantitative Analysis.**
- Topics include:
  1. Introduction to Artificial Intelligence in Finance and Quantitative Analysis
  2. AI in FinTech: Metaverse, Web3, DeFi, NFT, Financial Services Innovation and Applications
  3. Investing Psychology and Behavioral Finance
  4. Event Studies in Finance
  5. Finance Theory
  6. Data-Driven Finance
  7. Financial Econometrics
  8. AI-First Finance
  9. Deep Learning in Finance
  10. Reinforcement Learning in Finance
  11. Algorithmic Trading, Risk Management, Trading Bot and Event-Based Backtesting
  12. Case Study on AI in Finance and Quantitative Analysis.

# Core Competence

- **Exploring new knowledge in information technology, system development and application 80 %**
- **Internet marketing planning ability 10 %**
- **Thesis writing and independent research skills 10 %**

# Four Fundamental Qualities

- **Professionalism**
  - **Creative thinking and Problem-solving 40 %**
  - **Comprehensive Integration 40 %**
- **Interpersonal Relationship**
  - **Communication and Coordination 10 %**
  - **Teamwork 5 %**
- **Ethics**
  - **Honesty and Integrity 0 %**
  - **Self-Esteem and Self-reflection 0 %**
- **International Vision**
  - **Caring for Diversity 0 %**
  - **Interdisciplinary Vision 5 %**

# College Learning Goals

- **Ethics/Corporate Social Responsibility**
- **Global Knowledge/Awareness**
- **Communication**
- **Analytical and Critical Thinking**



# Department Learning Goals

- **Information Technologies and System Development Capabilities**
- **Internet Marketing Management Capabilities**
- **Research capabilities**

# Syllabus

Week	Date	Subject/Topics
1	2022/09/13	Introduction to Artificial Intelligence in Finance and Quantitative Analysis
2	2022/09/20	AI in FinTech: Metaverse, Web3, DeFi, NFT, Financial Services Innovation and Applications
3	2022/09/27	Investing Psychology and Behavioral Finance
4	2022/10/04	Event Studies in Finance
5	2022/10/11	Case Study on AI in Finance and Quantitative Analysis I
6	2022/10/18	Finance Theory

# Syllabus

Week	Date	Subject/Topics
7	2022/10/25	Data-Driven Finance
8	2022/11/01	Midterm Project Report
9	2022/11/08	Financial Econometrics
10	2022/11/15	AI-First Finance
11	2022/11/22	Industry Practices of AI in Finance and Quantitative Analysis
12	2022/11/29	Case Study on AI in Finance and Quantitative Analysis II

# Syllabus

<b>Week</b>	<b>Date</b>	<b>Subject/Topics</b>
<b>13</b>	<b>2022/12/06</b>	<b>Deep Learning in Finance; Reinforcement Learning in Finance</b>
<b>14</b>	<b>2022/12/13</b>	<b>Algorithmic Trading; Risk Management; Trading Bot and Event-Based Backtesting</b>
<b>15</b>	<b>2022/12/20</b>	<b>Final Project Report I</b>
<b>16</b>	<b>2022/12/27</b>	<b>Final Project Report II</b>
<b>17</b>	<b>2023/01/03</b>	<b>Self-learning</b>
<b>18</b>	<b>2023/01/10</b>	<b>Self-learning</b>

# Teaching Methods and Activities

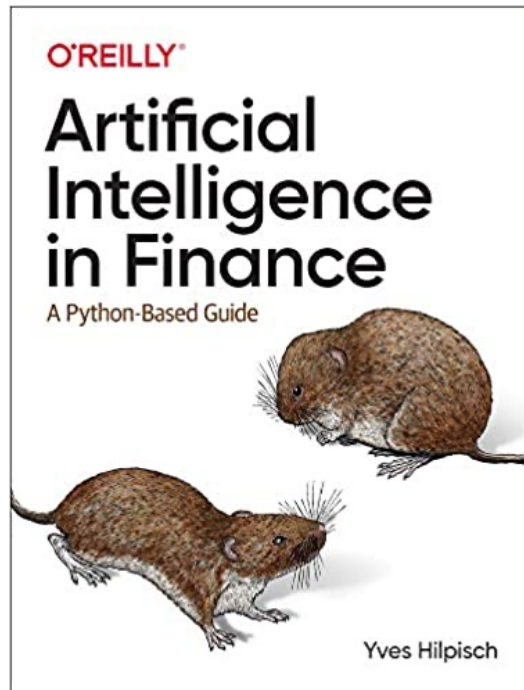
- **Lecture**
- **Discussion**
- **Practicum**

# Evaluation Methods

- **Individual Presentation 60 %**
- **Group Presentation 10 %**
- **Case Report 10 %**
- **Class Participation 10 %**
- **Assignment 10 %**

# Required Texts

- **Yves Hilpisch (2020),  
Artificial Intelligence in Finance: A Python-Based Guide,  
O'Reilly Media.**



# Reference Books

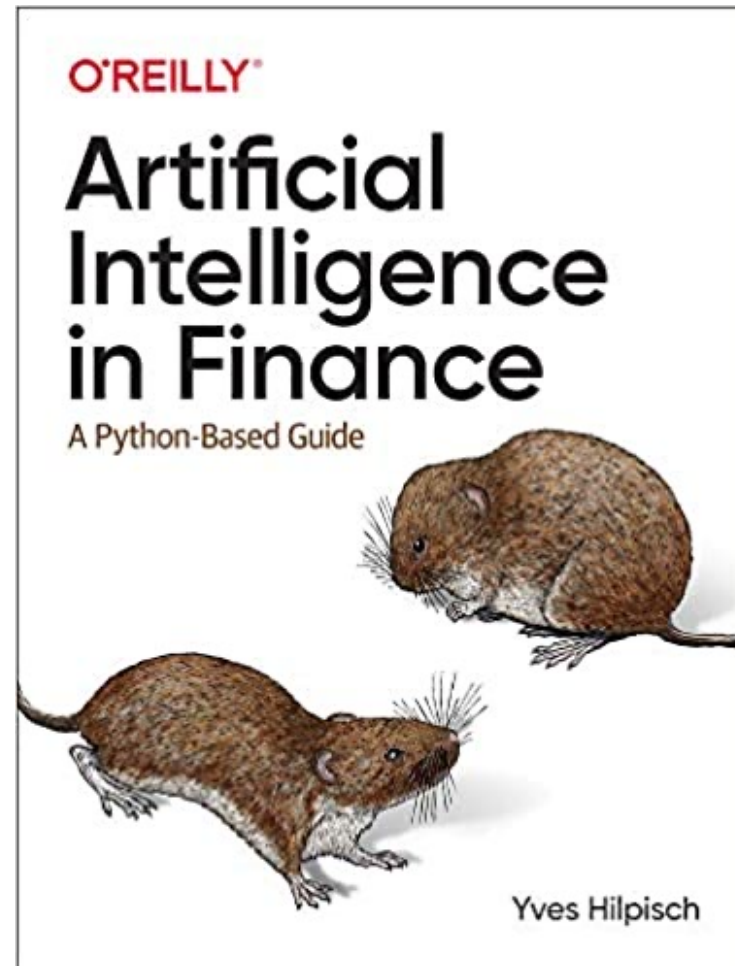
- **Stefan Jansen (2020), Machine Learning for Algorithmic Trading: Predictive models to extract signals from market and alternative data for systematic trading strategies with Python, 2nd Edition, Packt Publishing.**
- **Aurélien Géron (2019), Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, 2nd Edition, O'Reilly Media.**
- **Hariom Tatsat, Sahil Puri, Brad Lookabaugh (2020), Machine Learning and Data Science Blueprints for Finance: From Building Trading Strategies to Robo-Advisors Using Python, O'Reilly Media**
- **Chris Kelliher (2022), Quantitative Finance With Python: A Practical Guide to Investment Management, Trading, and Financial Engineering, Chapman and Hall/CRC.**
- **Abdullah Karasan (2021), Machine Learning for Financial Risk Management with Python: Algorithms for Modeling Risk, O'Reilly Media.**
- **Yves Hilpisch (2018), Python for Finance: Mastering Data-Driven Finance, 2nd Edition, O'Reilly Media.**



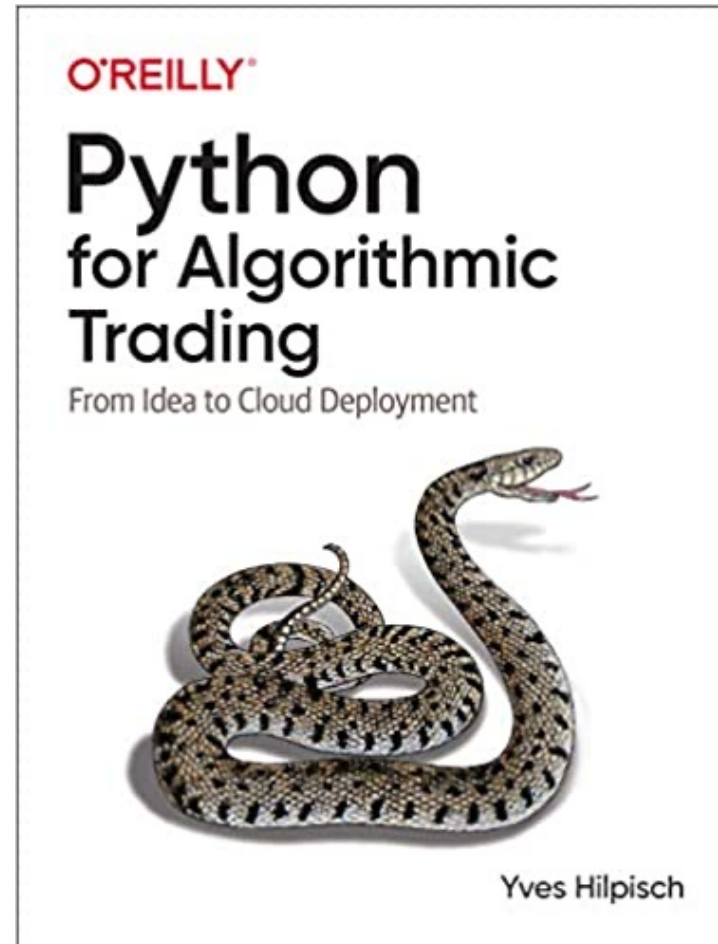
# Other References

- **Paolo Sironi (2016), FinTech Innovation: From Robo-Advisors to Goal Based Investing and Gamification, Wiley.**
- **Yves Hilpisch (2020), Financial Theory with Python: A Gentle Introduction, O'Reilly Media.**
- **Yves Hilpisch (2020), Python for Algorithmic Trading: From Idea to Cloud Deployment, O'Reilly Media.**
- **Yuxing Yan (2017), Python for Finance: Apply powerful finance models and quantitative analysis with Python, Second Edition, Packt Publishing.**

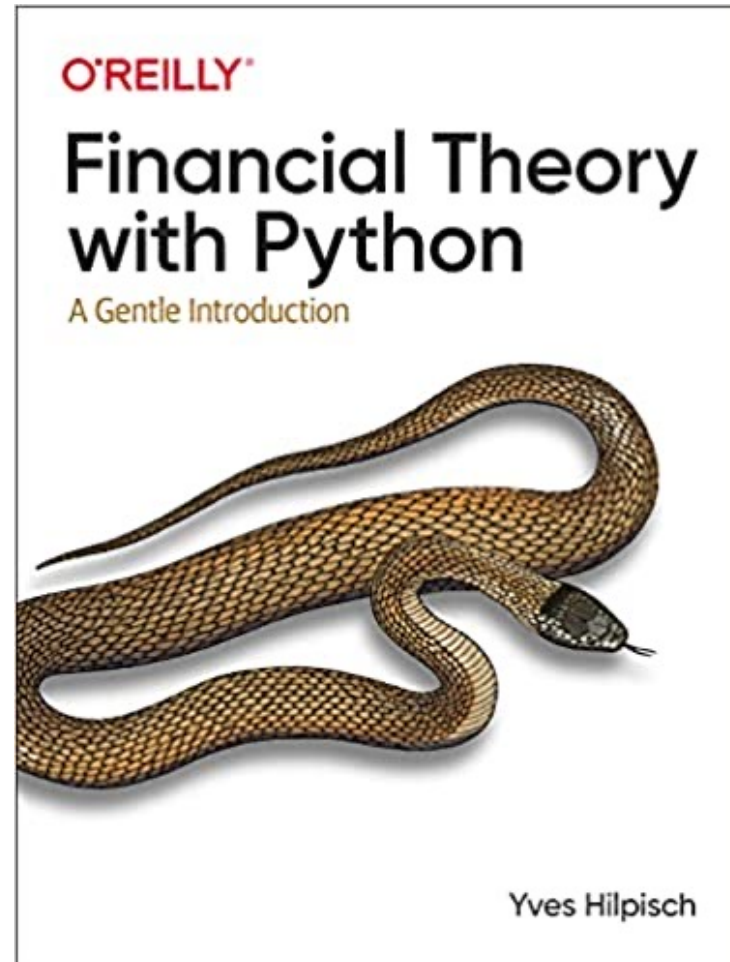
Yves Hilpisch (2020),  
**Artificial Intelligence in Finance:**  
**A Python-Based Guide,**  
O'Reilly



Yves Hilpisch (2020),  
**Python for Algorithmic Trading:**  
From Idea to Cloud Deployment,  
O'Reilly



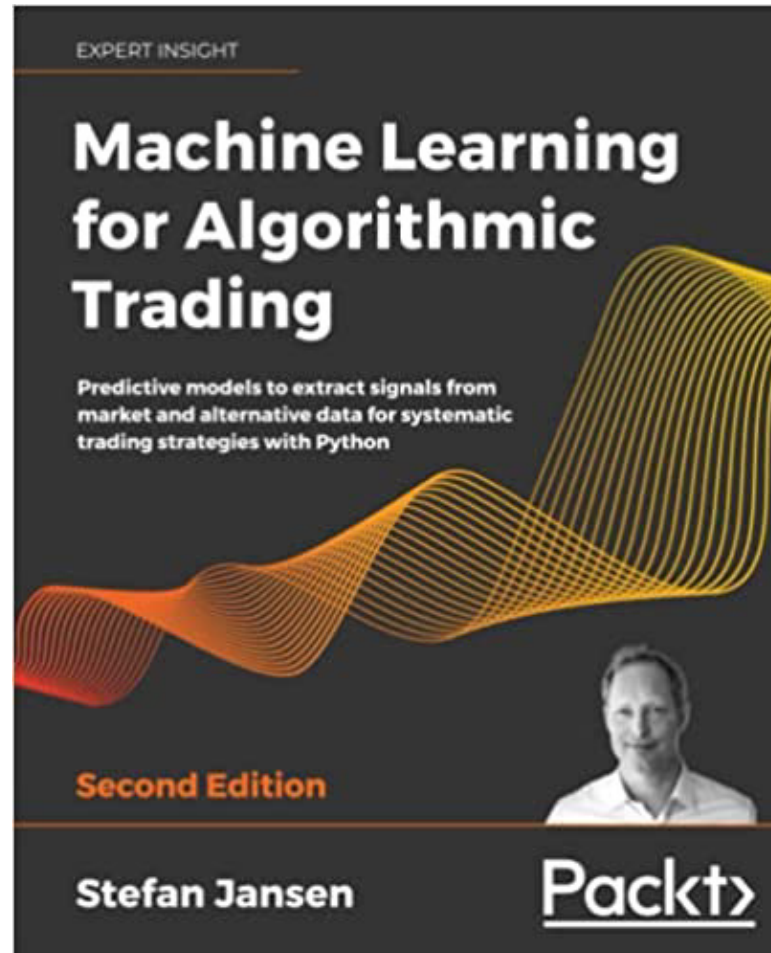
Yves Hilpisch (2021),  
**Financial Theory with Python:**  
**A Gentle Introduction,**  
O'Reilly



Stefan Jansen (2020),

# Machine Learning for Algorithmic Trading:

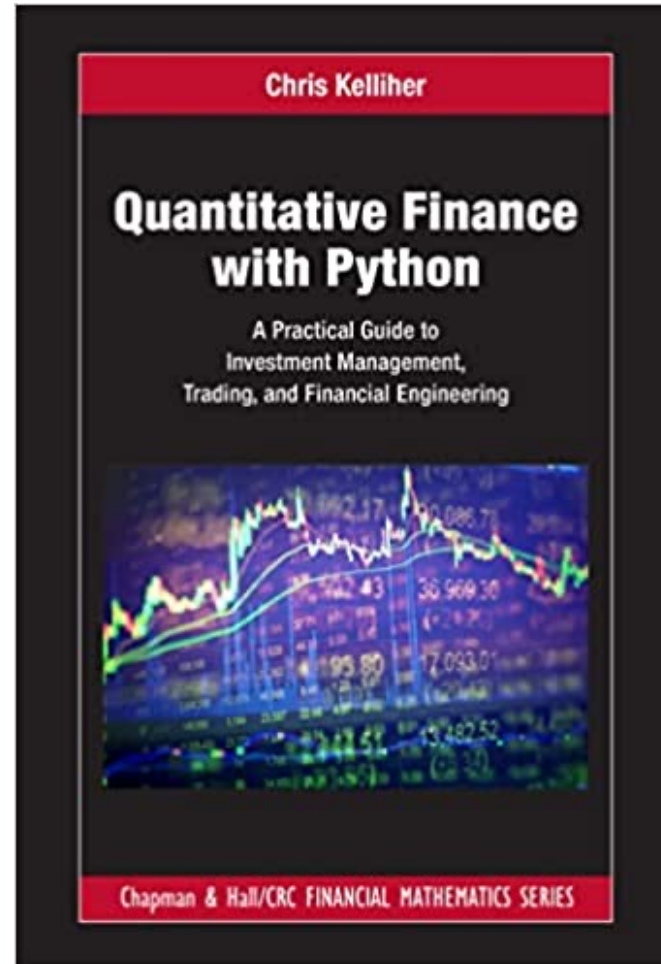
Predictive models to extract signals from market and alternative data for systematic trading strategies with Python, 2nd Edition,  
Packt Publishing.



**Chris Kelliher (2022),**

**Quantitative Finance With Python:**

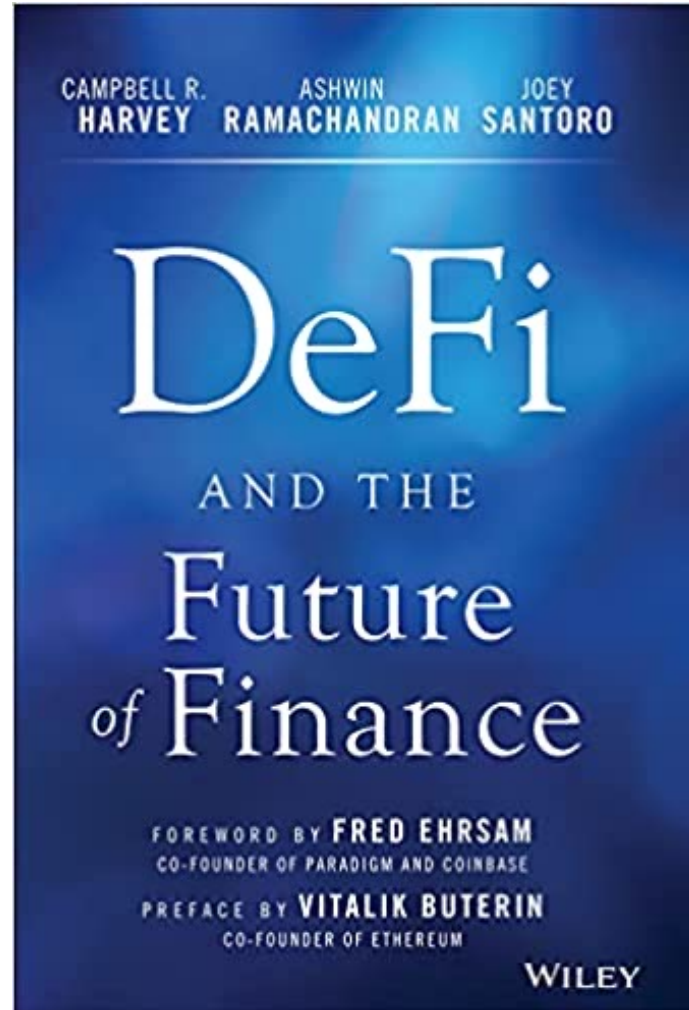
**A Practical Guide to Investment Management, Trading, and Financial Engineering,  
Chapman and Hall/CRC.**



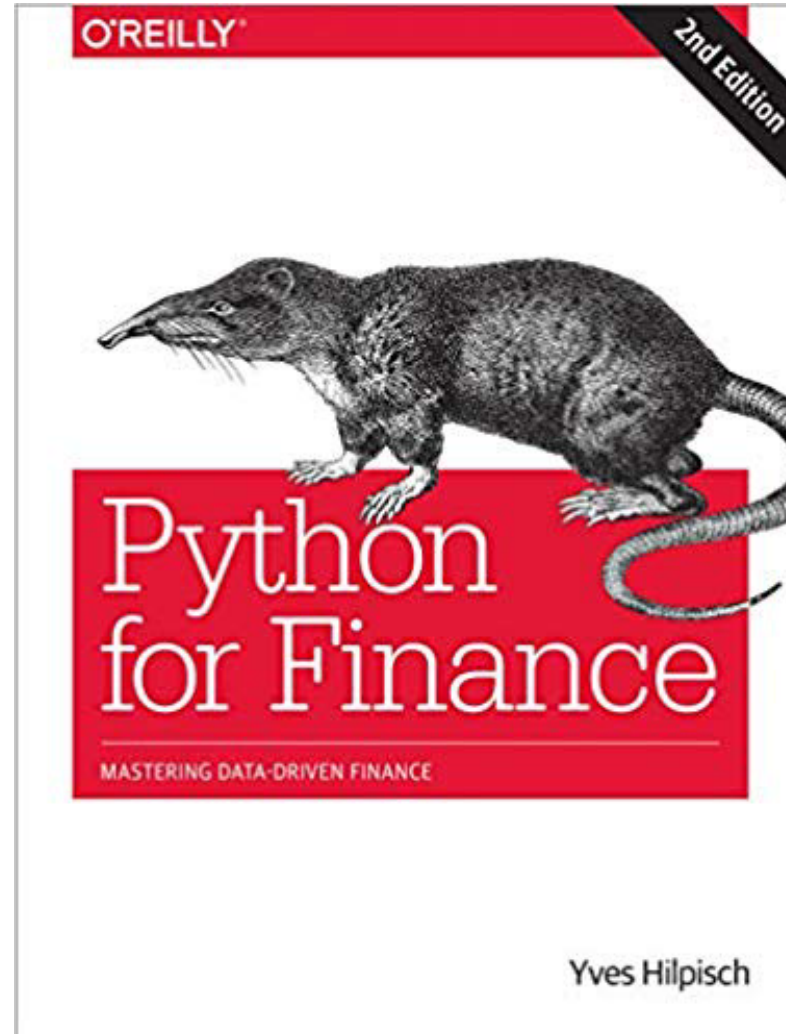
Campbell R. Harvey, Ashwin Ramachandran, Joey Santoro, Fred Ehrsam (2021),

# DeFi and the Future of Finance,

Wiley



Yves Hilpisch (2018),  
**Python for Finance: Mastering Data-Driven Finance,**  
O'Reilly





Paolo Sironi (2016)

# FinTech Innovation:

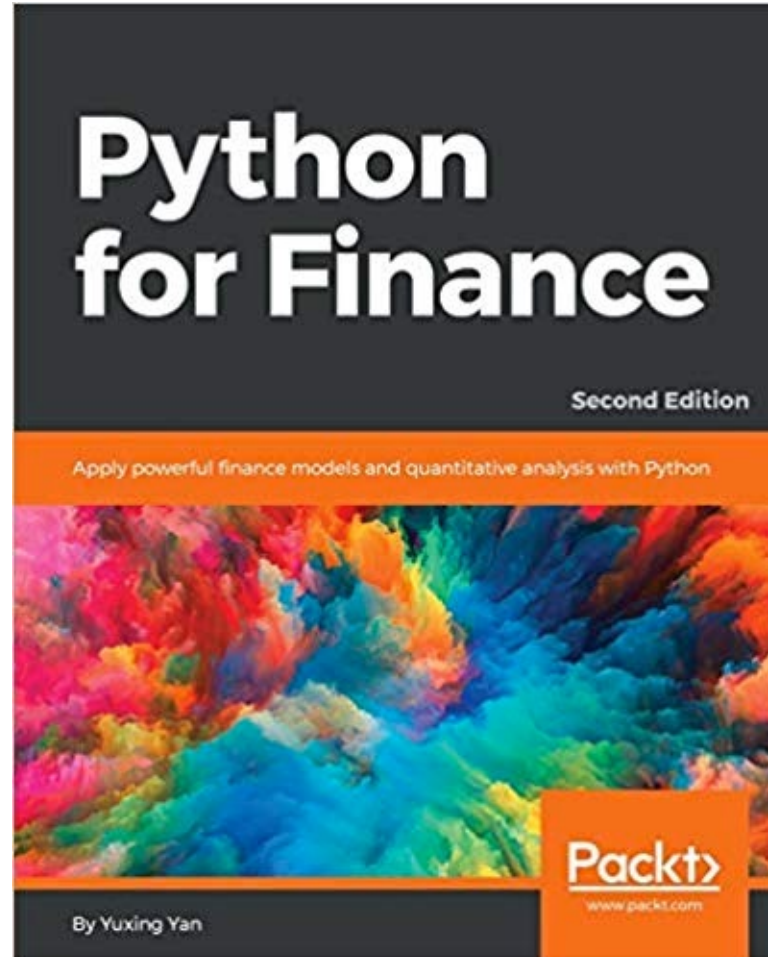
From Robo-Advisors to Goal Based Investing and Gamification,  
Wiley



Doron Kliger and Gregory Gurevich (2014),  
**Event Studies for Financial Research:**  
**A Comprehensive Guide,**  
Palgrave Macmillan



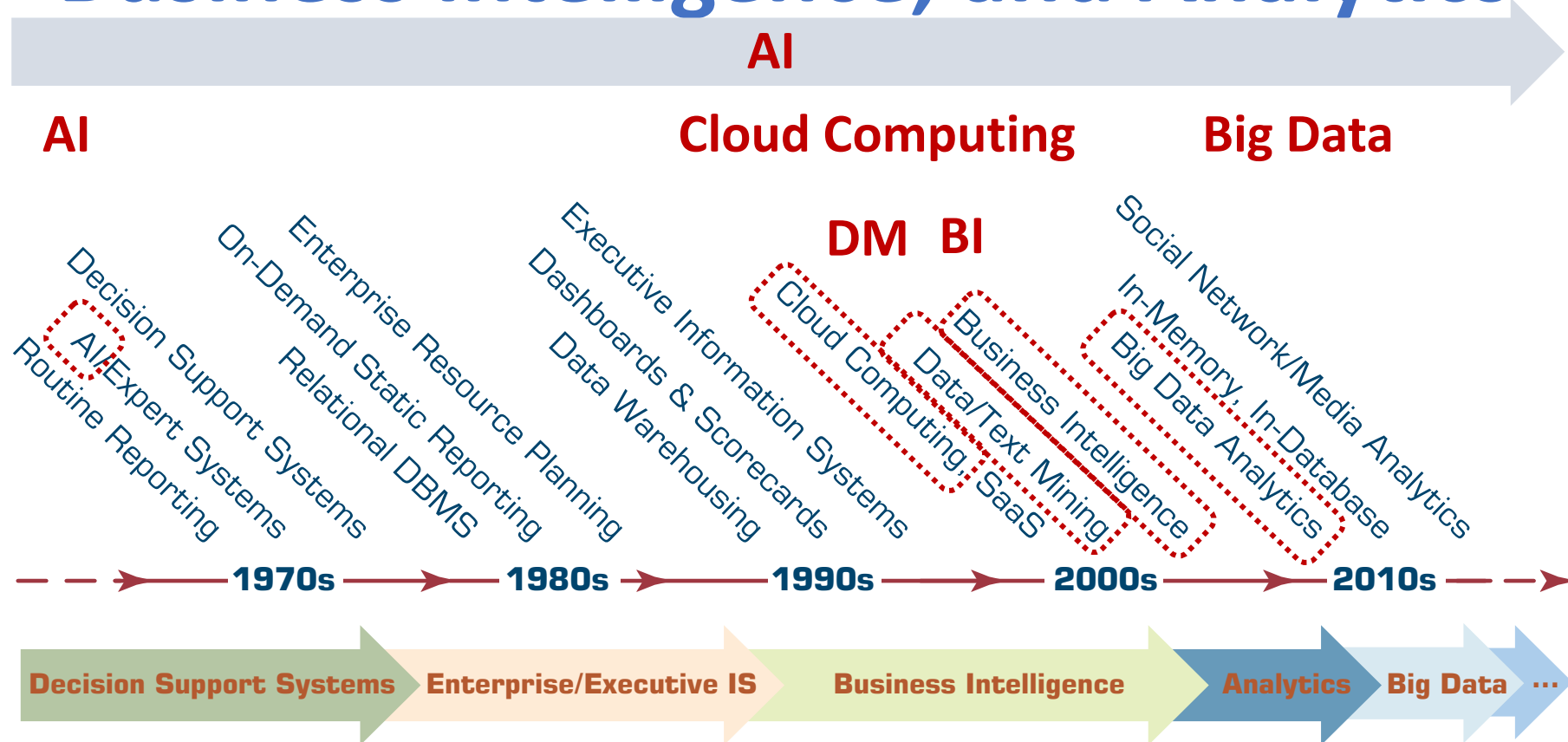
Yuxing Yan (2017),  
**Python for Finance: Apply powerful finance models  
and quantitative analysis with Python**, Second Edition,  
Packt Publishing



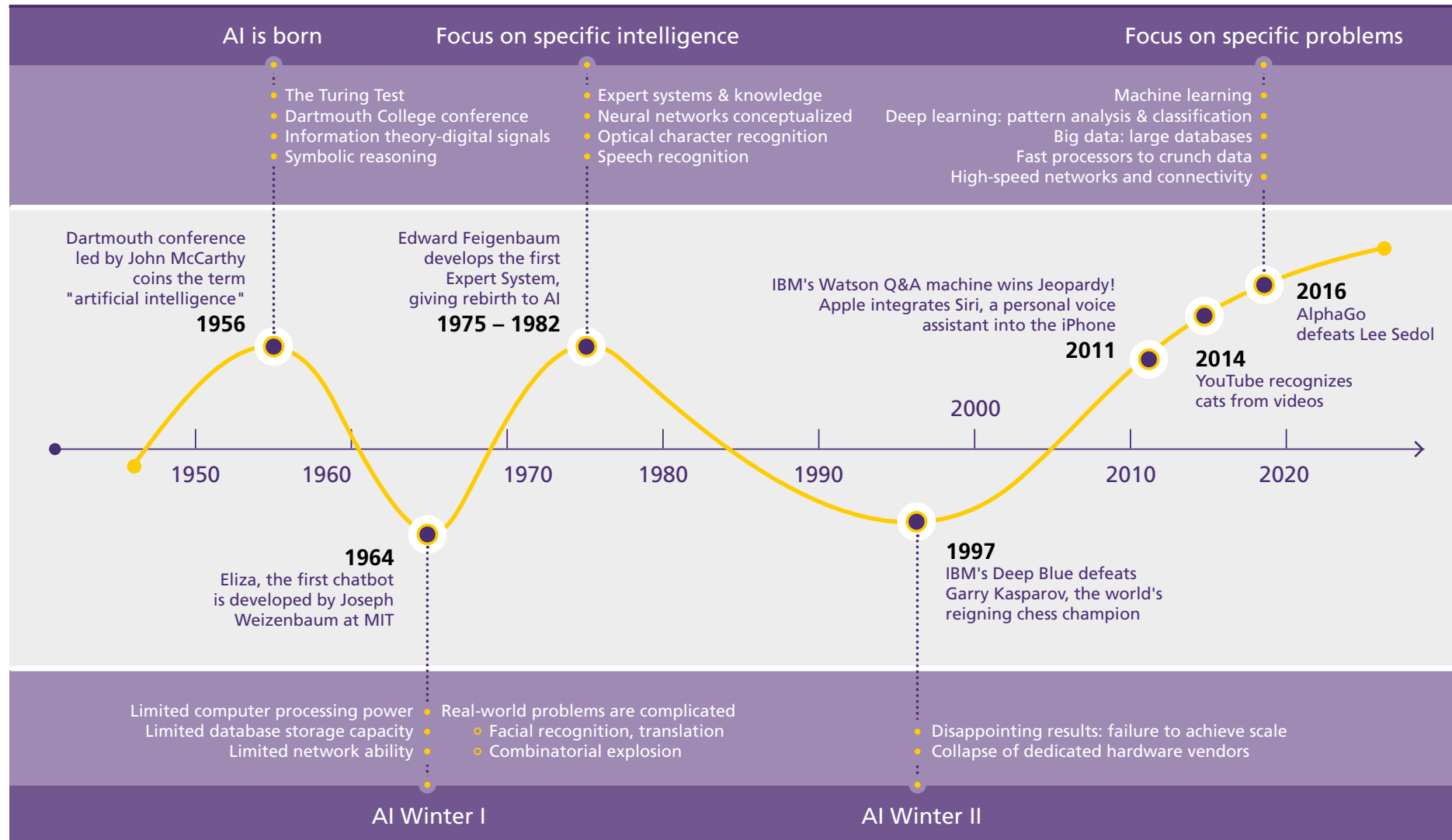
# Artificial Intelligence (AI)

# AI, Big Data, Cloud Computing

## Evolution of Decision Support, Business Intelligence, and Analytics



# The Rise of AI



# **Definition of Artificial Intelligence (A.I.)**

# Artificial Intelligence

**“... the science and  
engineering  
of  
making  
intelligent machines”**

**(John McCarthy, 1955)**



# Artificial Intelligence

**“... technology that  
thinks and acts  
like humans”**

# Artificial Intelligence

**“... intelligence  
exhibited by machines  
or software”**

# 4 Approaches of AI

<b>Thinking Humanly</b>	<b>Thinking Rationally</b>
<b>Acting Humanly</b>	<b>Acting Rationally</b>

# 4 Approaches of AI

<p><b>2.</b> <b>Thinking Humanly: The Cognitive Modeling Approach</b></p>	<p><b>3.</b> <b>Thinking Rationally: The “Laws of Thought” Approach</b></p>
<p><b>1.</b> <b>Acting Humanly: The Turing Test Approach</b> (1950)</p>	<p><b>4.</b> <b>Acting Rationally: The Rational Agent Approach</b></p>

# AI Acting Humanly: The Turing Test Approach

(Alan Turing, 1950)

- Knowledge Representation
- Automated Reasoning
- Machine Learning (ML)
  - Deep Learning (DL)
- Computer Vision (Image, Video)
- Natural Language Processing (NLP)
- Robotics

# FinTech

# Financial Technology

# FinTech





# Financial Technology

## FinTech

**“providing  
financial services  
by making use of  
software and  
modern technology”**

# Financial Revolution with Fintech

## A financial services revolution

### Consumer Trends



1. Simplification



2. Transparency



3. Analytics



4. Reduced Friction

# FinTech: Financial Services Innovation



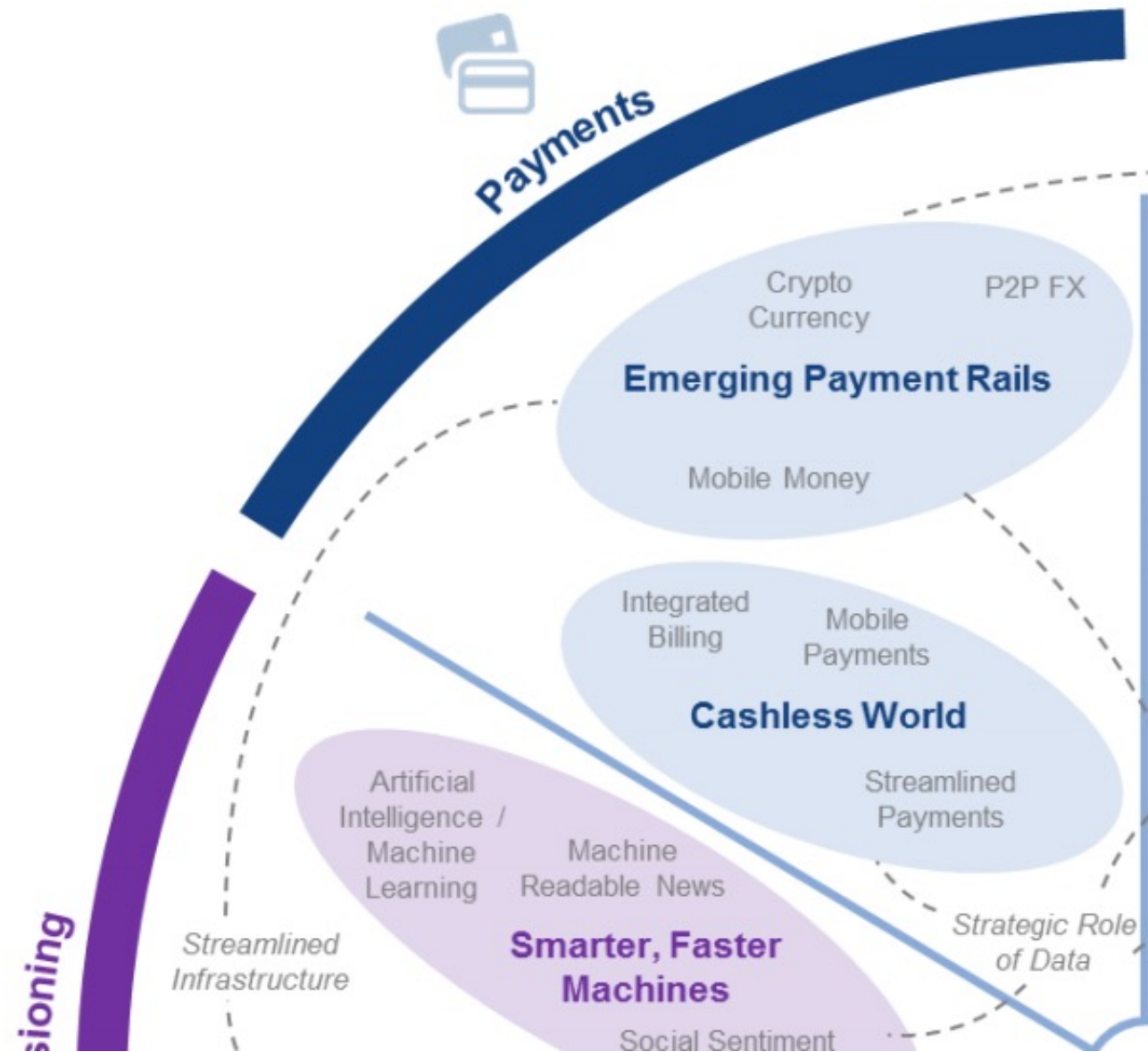
# **FinTech:**

## **Financial Services Innovation**

- 1. Payments**
- 2. Insurance**
- 3. Deposits & Lending**
- 4. Capital Raising**
- 5. Investment Management**
- 6. Market Provisioning**

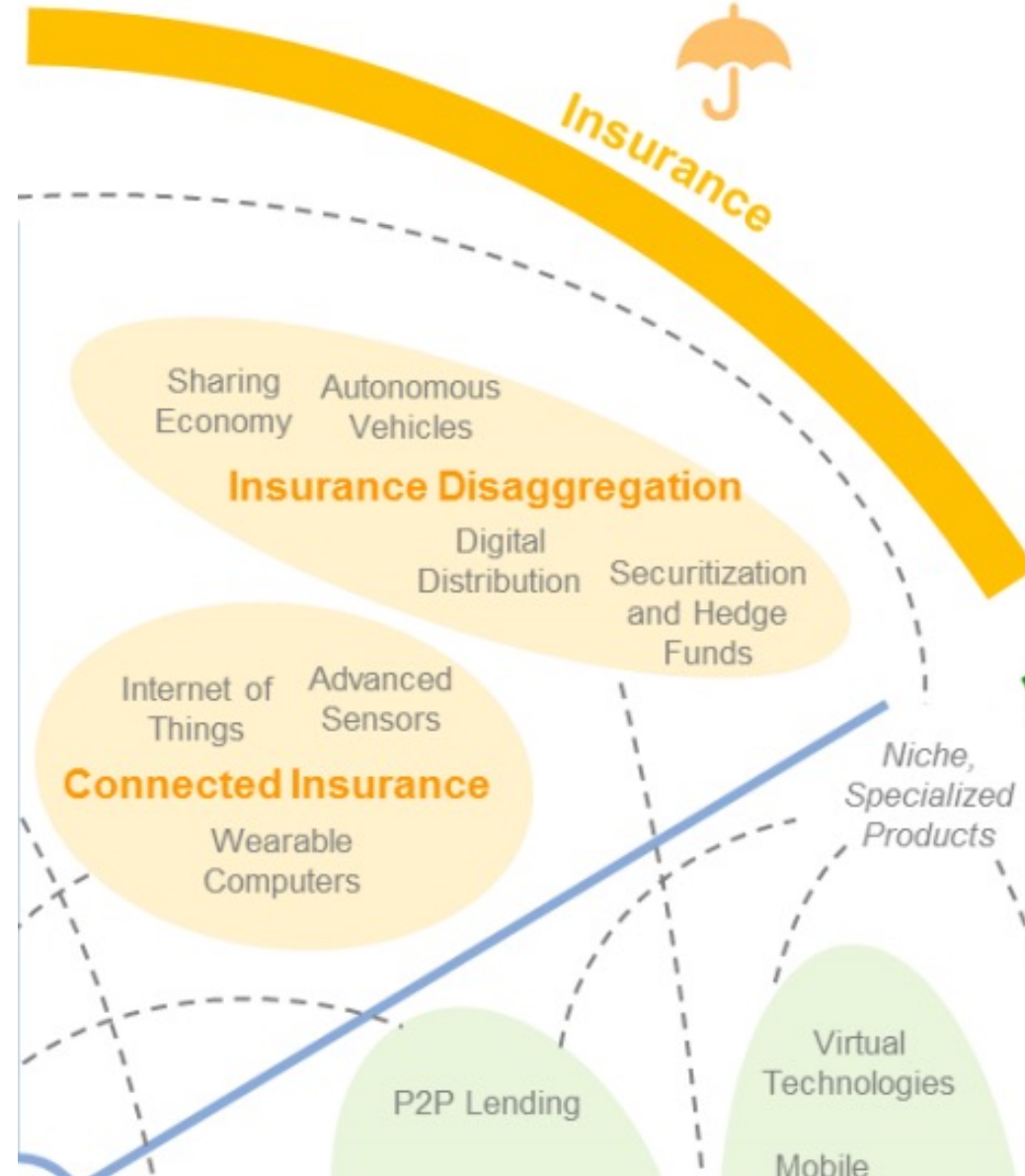
# 1

# FinTech: Payment



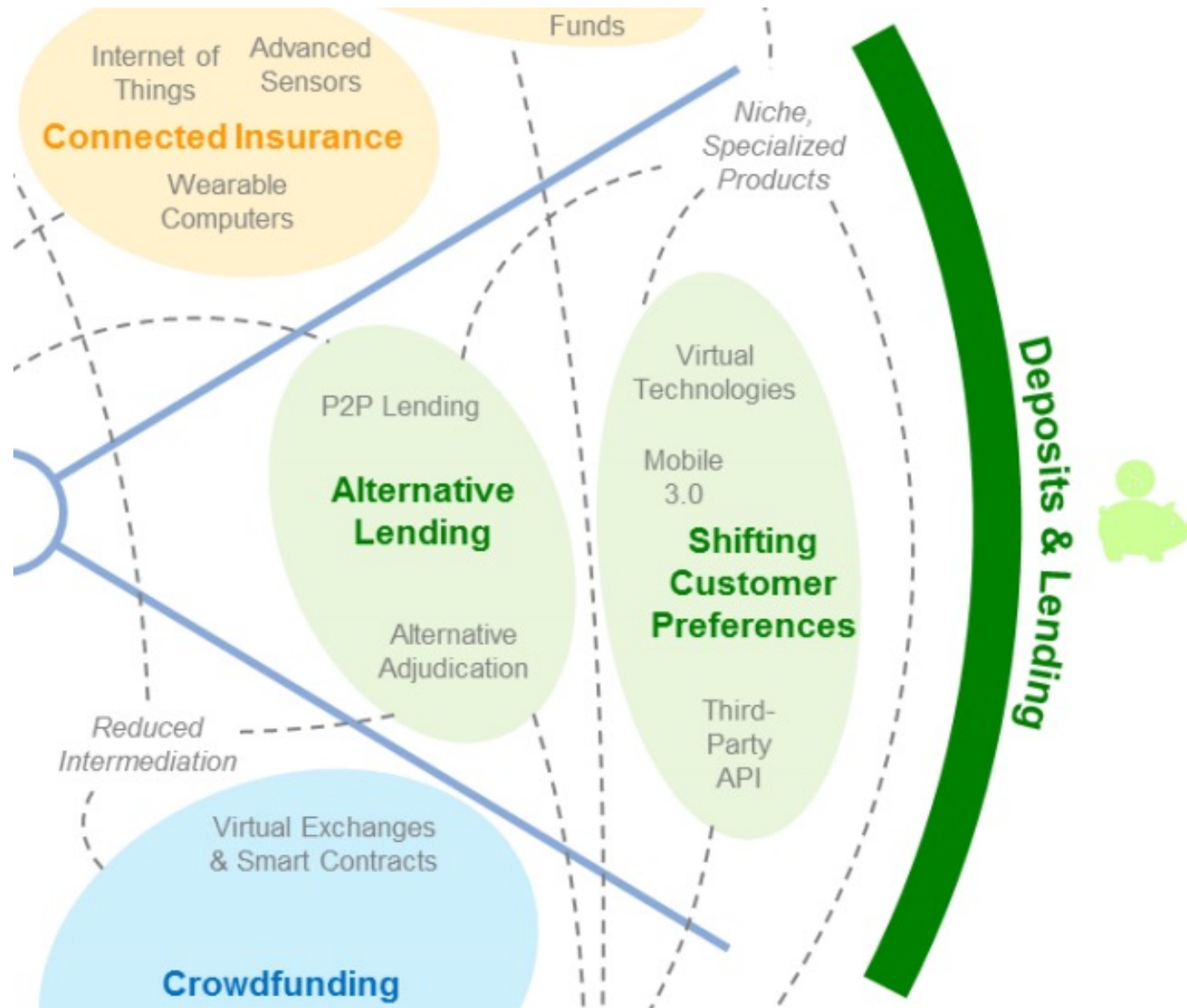
# 2

# FinTech: Insurance



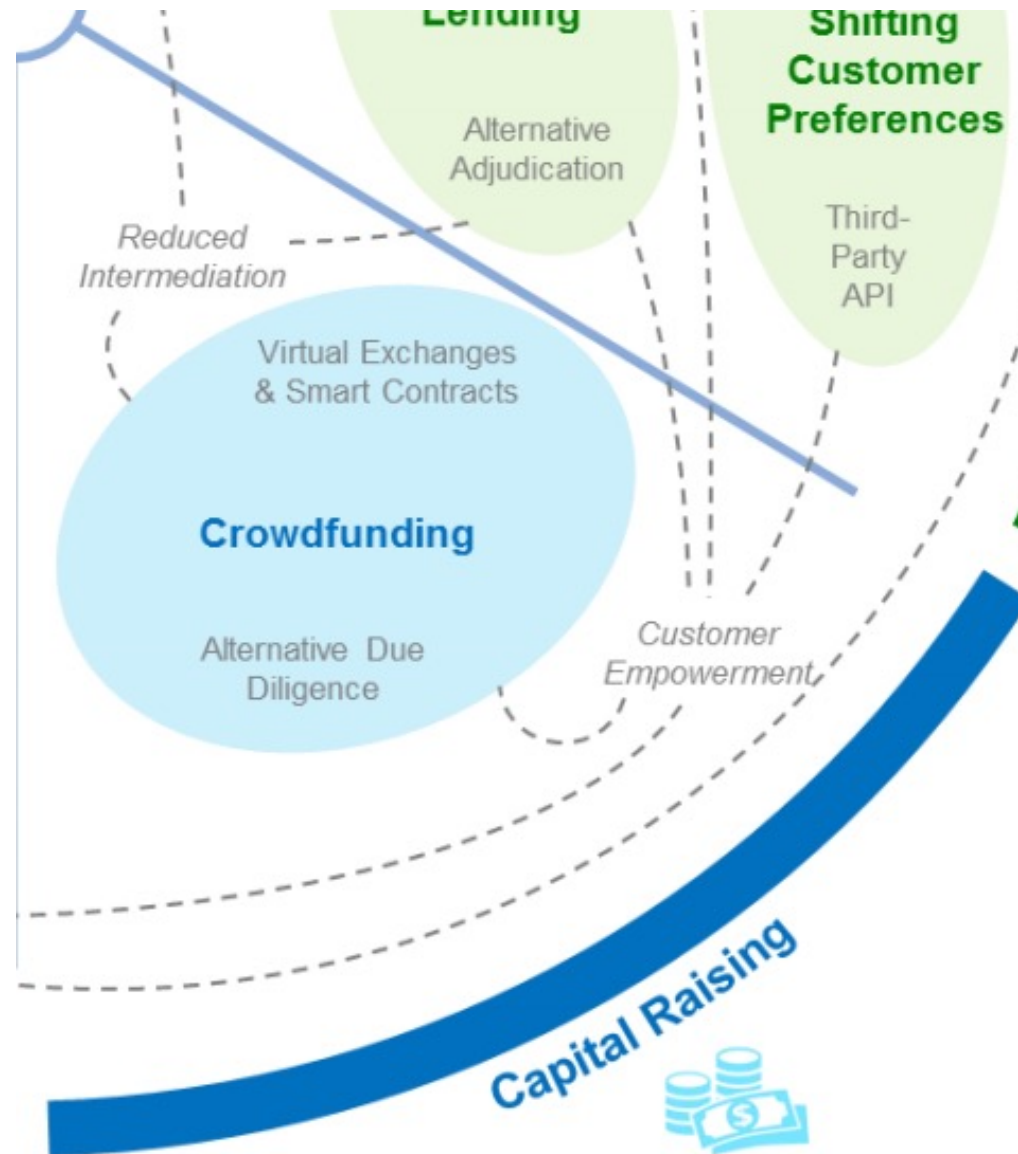
# 3

## FinTech: Deposits & Lending



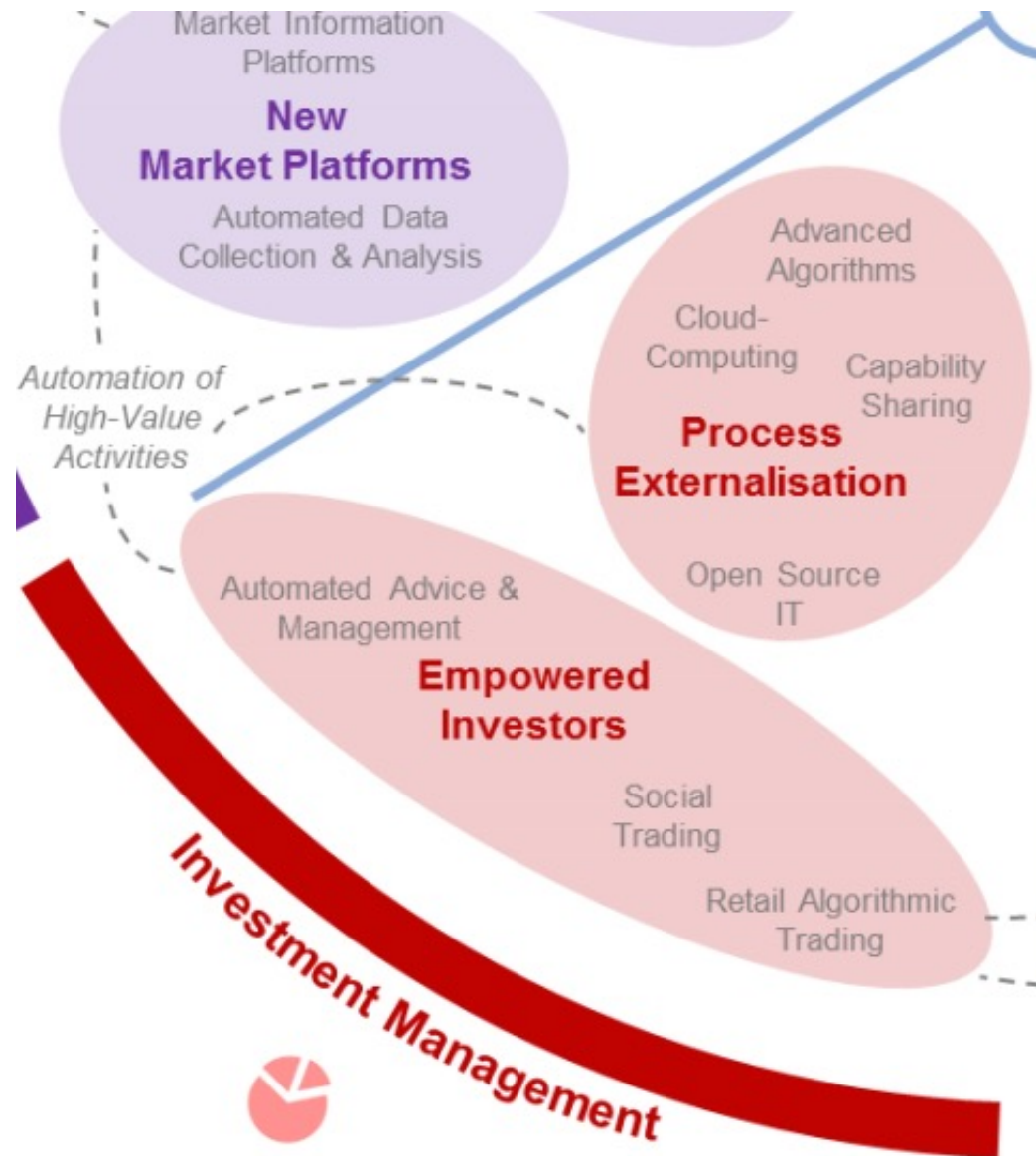
# 4

## FinTech: Capital Raising



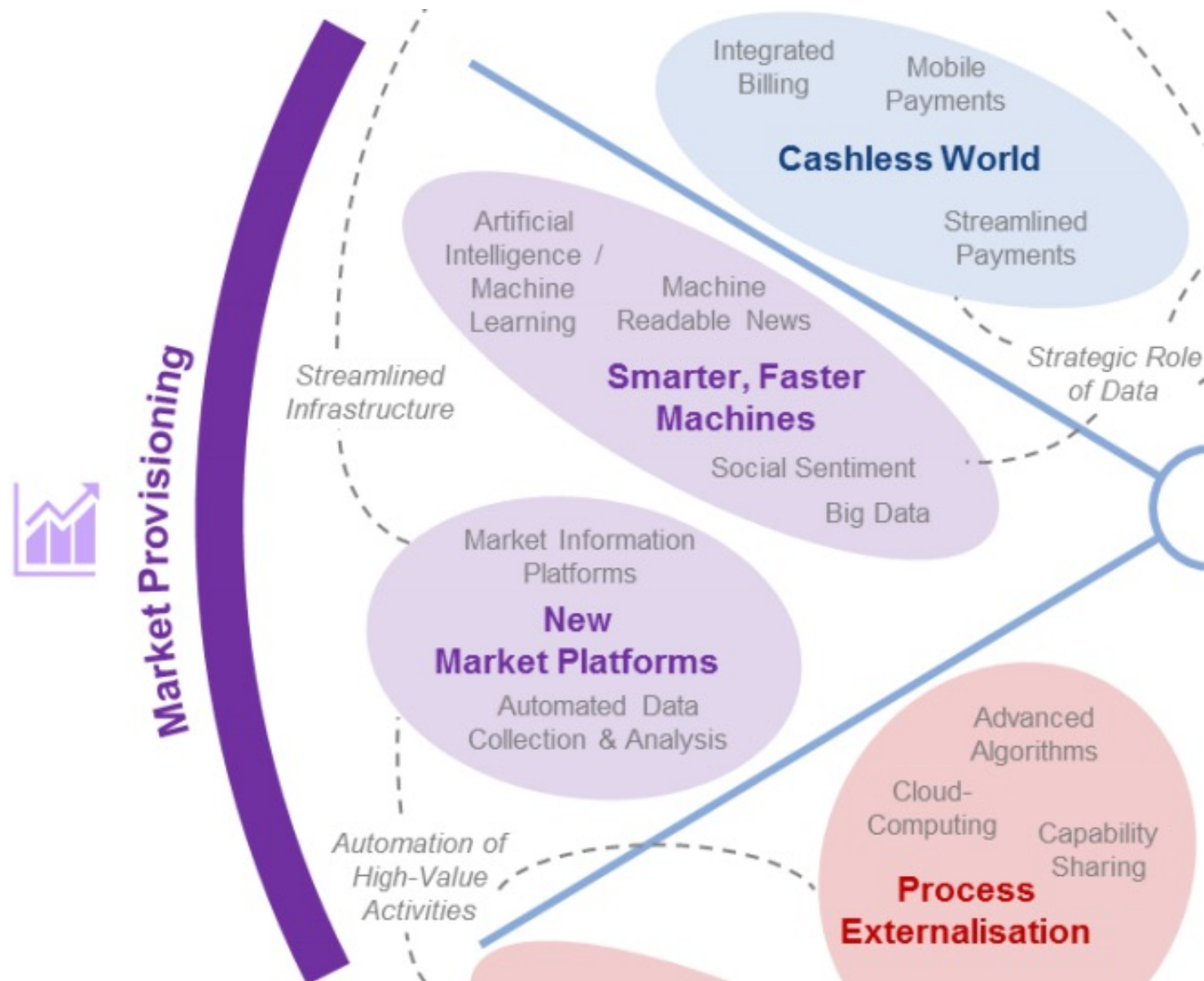


# 5 FinTech: Investment Management



# 6

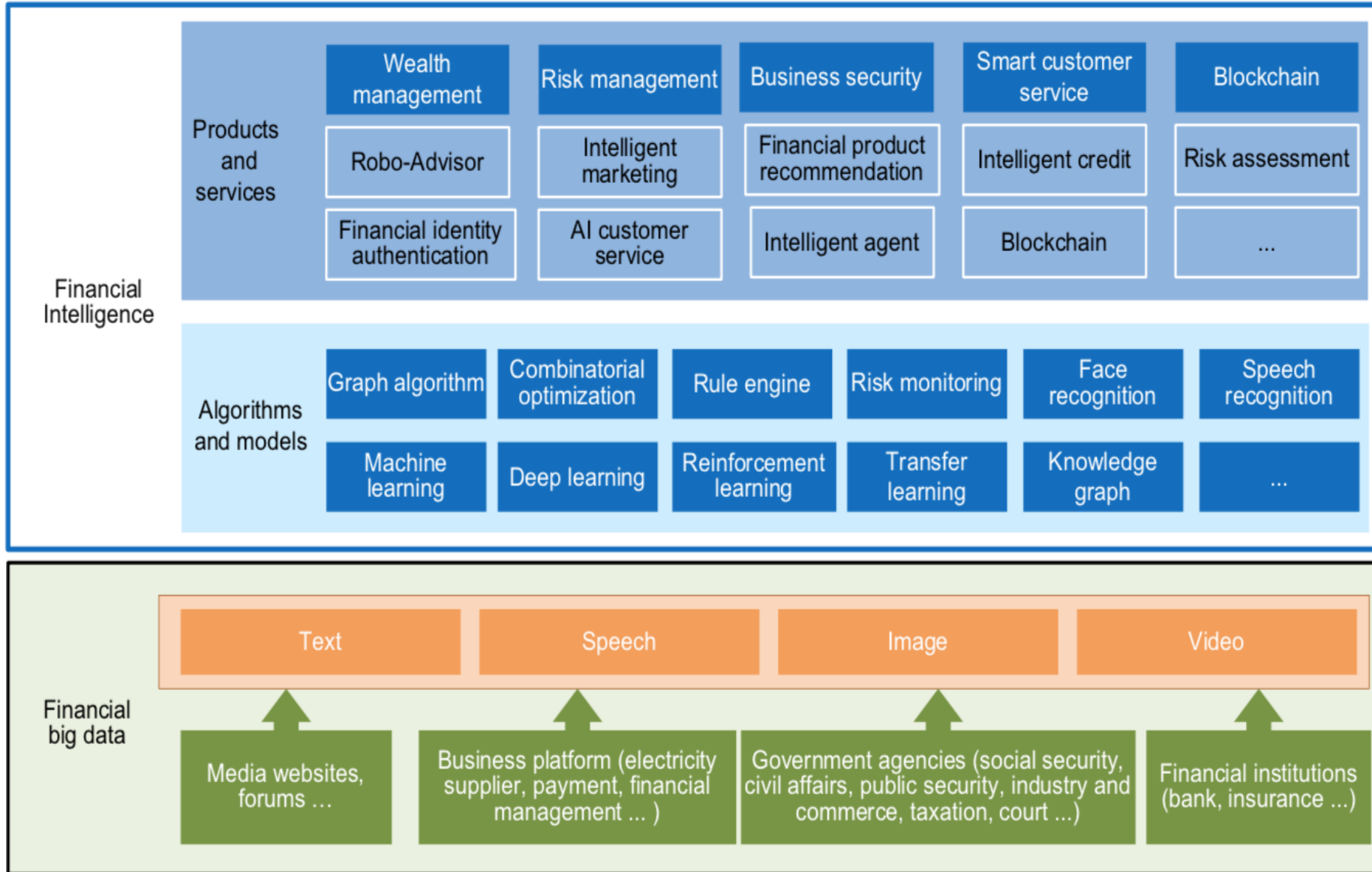
# FinTech: Market Provisioning



**AI**  
**in**  
**FinTech**

# FinBrain: when Finance meets AI 2.0

(Zheng et al., 2019)



Source: Xiao-lin Zheng, Meng-ying Zhu, Qi-bing Li, Chao-chao Chen, and Yan-chao Tan (2019), "Finbrain: When finance meets AI 2.0." Frontiers of Information Technology & Electronic Engineering 20, no. 7, pp. 914-924

# AI 2.0

**a new generation of AI  
based on the  
novel information environment of  
major changes and  
the development of  
new goals.**

# Technology-driven Financial Industry Development

Development stage	Driving technology	Main landscape	Inclusive finance	Relationship between technology and finance
Fintech 1.0 (financial IT)	Computer	Credit card, ATM, and CRMS	Low	Technology as a tool
Fintech 2.0 (Internet finance)	Mobile Internet	Marketplace lending, third-party payment, crowdfunding, and Internet insurance	Medium	Technology- driven change
Fintech 3.0 (financial intelligence)	AI, Big Data, Cloud Computing, Blockchain	Intelligent finance	High	Deep fusion

# **Deep learning for financial applications: A survey**

## **Applied Soft Computing (2020)**

Source:

Ahmet Murat Ozbayoglu, Mehmet Ugur Gudelek, and Omer Berat Sezer (2020). "Deep learning for financial applications: A survey." Applied Soft Computing (2020): 106384.

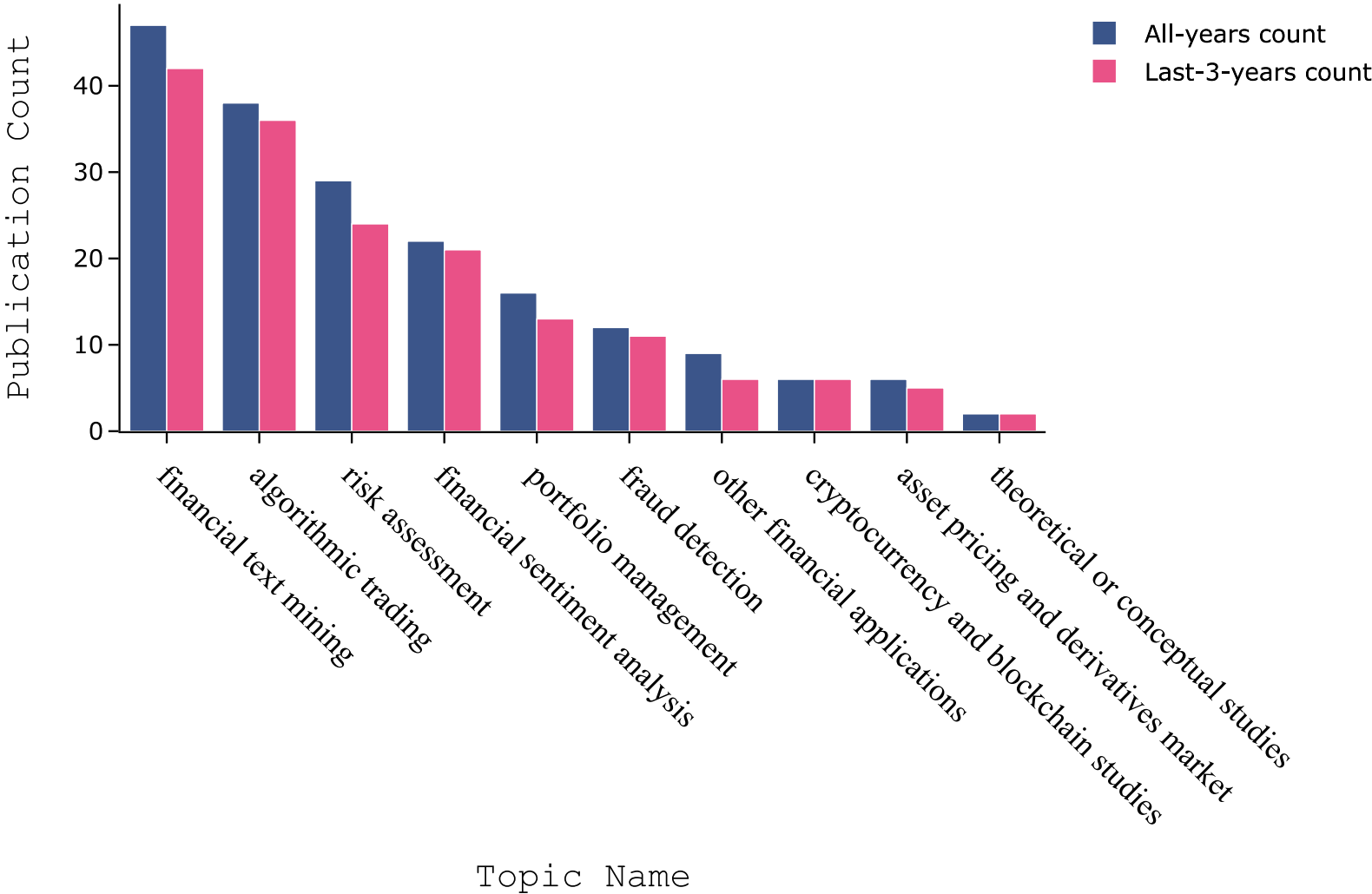
**Financial  
time series forecasting with  
deep learning:  
A systematic literature review:  
2005–2019  
Applied Soft Computing (2020)**

Source:

Omer Berat Sezer, Mehmet Ugur Gudelek, and Ahmet Murat Ozbayoglu (2020),  
"Financial time series forecasting with deep learning: A systematic literature review:  
2005–2019." *Applied Soft Computing* 90 (2020): 106181.

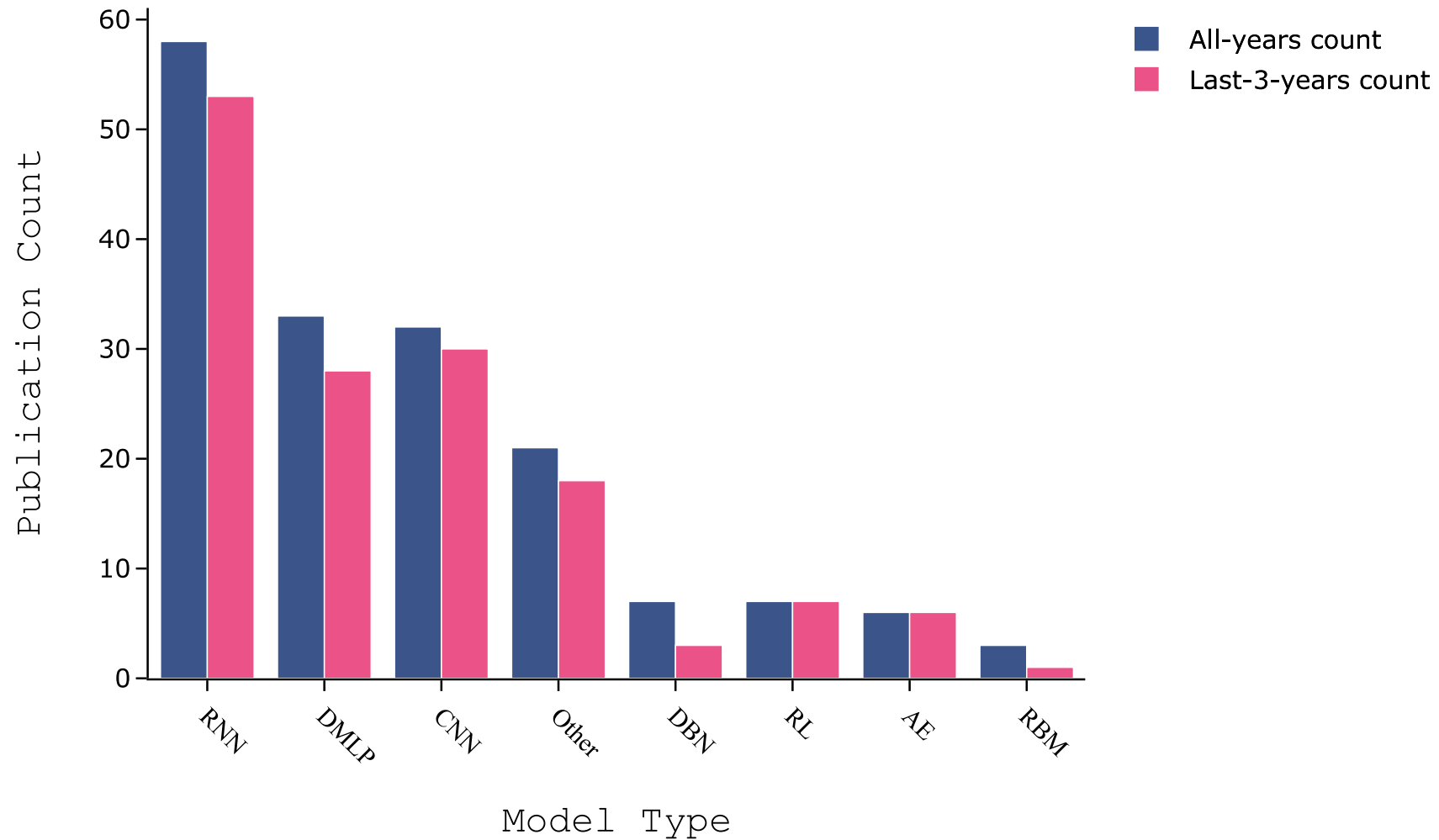


# Deep learning for financial applications: Topics

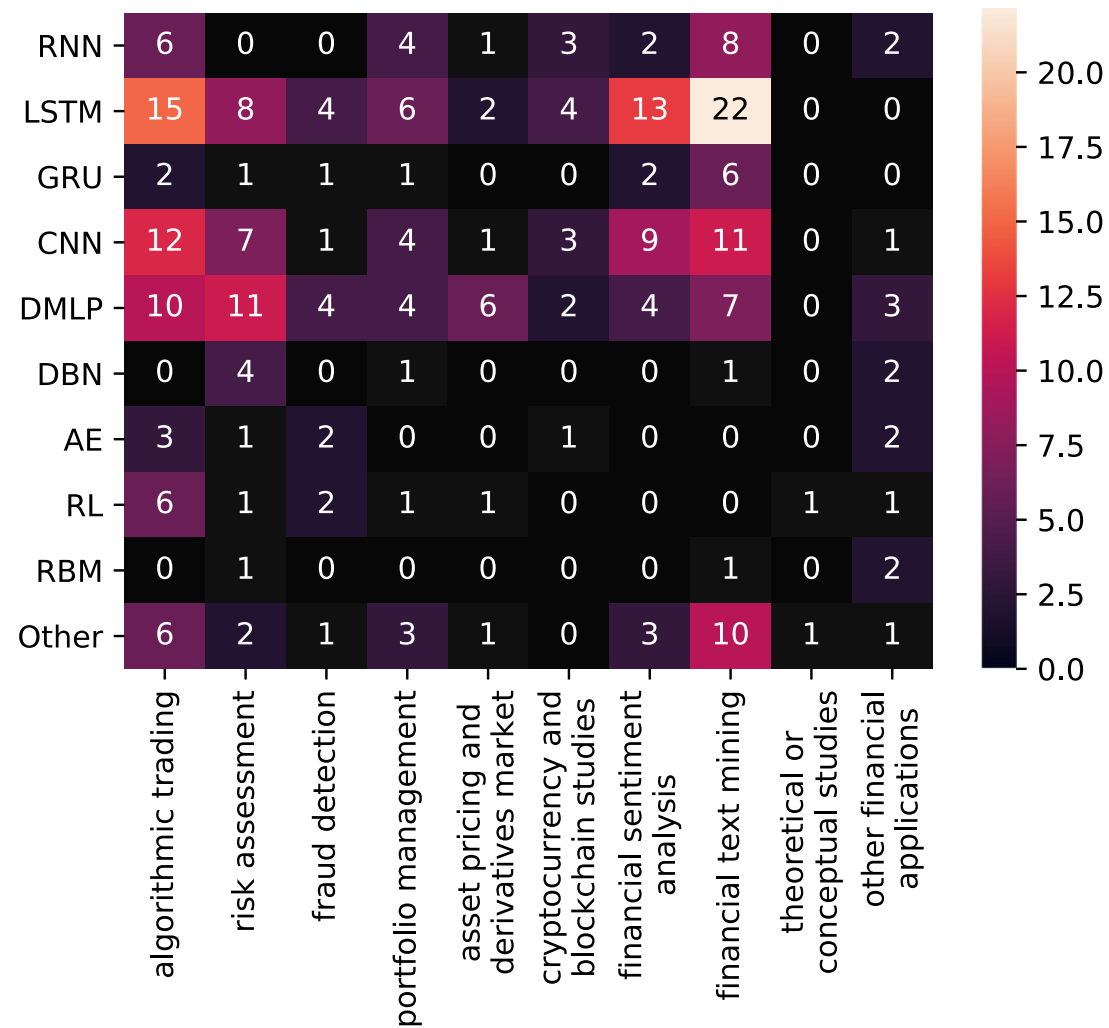


Source: Ahmet Murat Ozbayoglu, Mehmet Ugur Gudelek, and Omer Berat Sezer (2020). "Deep learning for financial applications: A survey." Applied Soft Computing (2020): 106384.

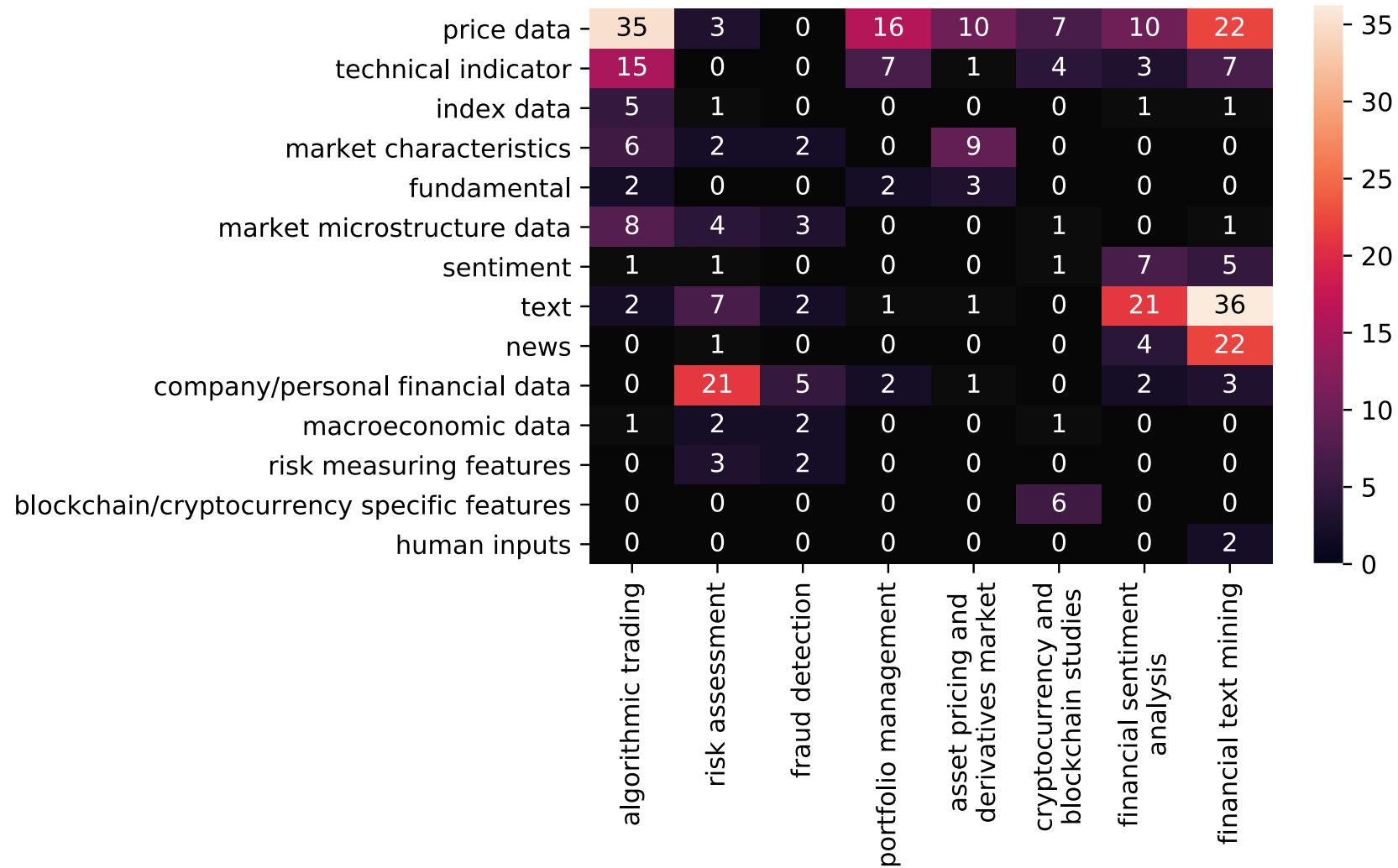
# Deep learning for financial applications: Deep Learning Models



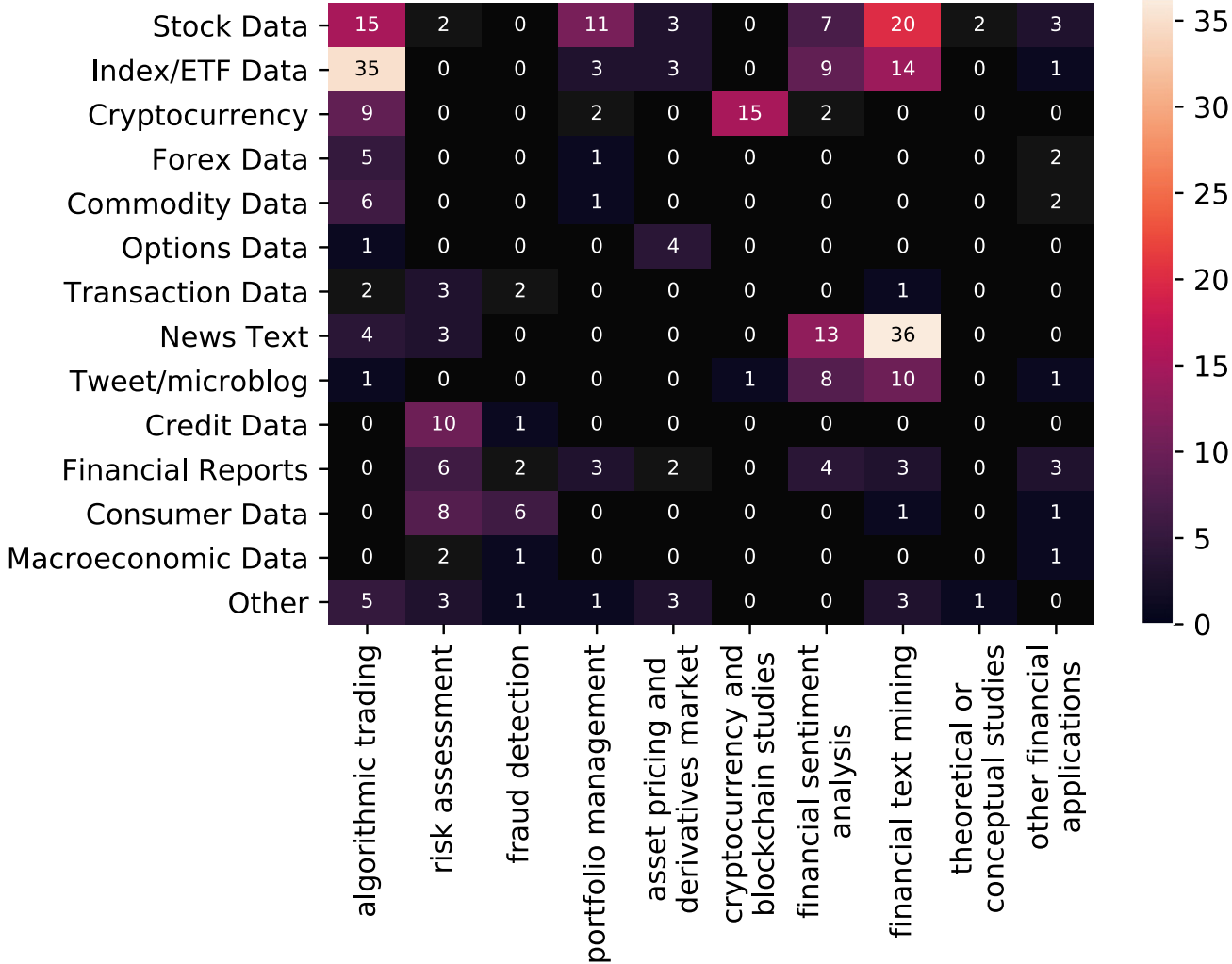
# Deep learning for financial applications: Topic-Model Heatmap



# Deep learning for financial applications: Topic-Feature Heatmap



# Deep learning for financial applications: Topic-Dataset Heatmap



Source: Ahmet Murat Ozbayoglu, Mehmet Ugur Gudelek, and Omer Berat Sezer (2020). "Deep learning for financial applications: A survey." Applied Soft Computing (2020): 106384.

# Deep learning for financial applications:

## Algo-trading applications embedded with time series forecasting models

Art.	Data set	Period	Feature set	Method	Performance criteria	Environment
[33]	GarantiBank in BIST, Turkey	2016	OCHLV, Spread, Volatility, Turnover, etc.	PLR, Graves LSTM	MSE, RMSE, MAE, RSE, Correlation R-square	Spark
[34]	CSI300, Nifty50, HSI, Nikkei 225, S&P500, DJIA	2010–2016	OCHLV, Technical Indicators	WT, Stacked autoencoders, LSTM	MAPE, Correlation coefficient, THEIL-U	–
[35]	Chinese Stocks	2007–2017	OCHLV	CNN + LSTM	Annualized Return, Mxm Retracement	Python
[36]	50 stocks from NYSE	2007–2016	Price data	SFM	MSE	–
[37]	The LOB of 5 stocks of Finnish Stock Market	2010	FI-2010 dataset: bid/ask and volume	WMTR, MDA	Accuracy, Precision, Recall, F1-Score	–
[38]	300 stocks from SZSE, Commodity	2014–2015	Price data	FDDR, DMLP+RL	Profit, return, SR, profit-loss curves	Keras
[39]	S&P500 Index	1989–2005	Price data, Volume	LSTM	Return, STD, SR, Accuracy	Python, TensorFlow, Keras, R, H2O
[40]	Stock of National Bank of Greece (ETE).	2009–2014	FTSE100, DJIA, GDAX, NIKKEI225, EUR/USD, Gold	GASVR, LSTM	Return, volatility, SR, Accuracy	Tensorflow
[41]	Chinese stock-IF-IH-IC contract	2016–2017	Decisions for price change	MODRL+LSTM	Profit and loss, SR	–
[42]	Singapore Stock Market Index	2010–2017	OCHL of last 10 days of Index	DMLP	RMSE, MAPE, Profit, SR	–
[43]	GBP/USD	2017	Price data	Reinforcement Learning + LSTM + NES	SR, downside deviation ratio, total profit	Python, Keras, Tensorflow
[44]	Commodity, FX future, ETF	1991–2014	Price Data	DMLP	SR, capability ratio, return	C++, Python
[45]	USD/GBP, S&P500, FTSE100, oil, gold	2016	Price data	AE + CNN	SR, % volatility, avg return/trans, rate of return	H2O

Source: Ahmet Murat Ozbayoglu, Mehmet Ugur Gudelek, and Omer Berat Sezer (2020). "Deep learning for financial applications: A survey." Applied Soft Computing (2020): 106384.

# Deep learning for financial applications:

## Algo-trading applications embedded with time series forecasting models

Art.	Data set	Period	Feature set	Method	Performance criteria	Environment
[46]	Bitcoin, Dash, Ripple, Monero, Litecoin, Dogecoin, Nxt, Namecoin	2014–2017	MA, BOLL, the CRIX returns, Euribor interest rates, OCHLV	LSTM, RNN, DMLP	Accuracy, F1-measure	Python, Tensorflow
[47]	S&P500, KOSPI, HSI, and EuroStoxx50	1987–2017	200-days stock price	Deep Q-Learning, DMLP	Total profit, Correlation	–
[48]	Stocks in the S&P500	1990–2015	Price data	DMLP, GBT, RF	Mean return, MDD, Calmar ratio	H2O
[49]	Fundamental and Technical Data, Economic Data	–	Fundamental , technical and market information	CNN	–	–

# Deep learning for financial applications:

## Classification (buy–sell signal, or trend detection) based algo-trading models

Art.	Data set	Period	Feature set	Method	Performance criteria	Environment
[51]	Stocks in Dow30	1997–2017	RSI	DMLP with genetic algorithm	Annualized return	Spark MLlib, Java
[52]	SPY ETF, 10 stocks from S&P500	2014–2016	Price data	FFNN	Cumulative gain	MatConvNet, Matlab
[53]	Dow30 stocks	2012–2016	Close data and several technical indicators	LSTM	Accuracy	Python, Keras, Tensorflow, TALIB
[54]	High-frequency record of all orders	2014–2017	Price data, record of all orders, transactions	LSTM	Accuracy	–
[55]	Nasdaq Nordic (Kesko Oyj, Outokumpu Oyj, Sampo, Rautaruukki, Wartsila Oyj)	2010	Price and volume data in LOB	LSTM	Precision, Recall, F1-score, Cohen's k	–
[56]	17 ETFs	2000–2016	Price data, technical indicators	CNN	Accuracy, MSE, Profit, AUROC	Keras, Tensorflow
[57]	Stocks in Dow30 and 9 Top Volume ETFs	1997–2017	Price data, technical indicators	CNN with feature imaging	Recall, precision, F1-score, annualized return	Python, Keras, Tensorflow, Java
[58]	FTSE100	2000–2017	Price data	CAE	TR, SR, MDD, mean return	–
[59]	Nasdaq Nordic (Kesko Oyj, Outokumpu Oyj, Sampo, Rautaruukki, Wartsila Oyj)	2010	Price, Volume data, 10 orders of the LOB	CNN	Precision, Recall, F1-score, Cohen's k	Theano, Scikit learn, Python
[60]	Borsa Istanbul 100 Stocks	2011–2015	75 technical indicators and OCHLV	CNN	Accuracy	Keras
[61]	ETFs and Dow30	1997–2007	Price data	CNN with feature imaging	Annualized return	Keras, Tensorflow
[62]	8 experimental assets from bond/derivative market	–	Asset prices data	RL, DMLP, Genetic Algorithm	Learning and genetic algorithm error	–
[63]	10 stocks from S&P500	–	Stock Prices	TDNN, RNN, PNN	Missed opportunities, false alarms ratio	–
[64]	London Stock Exchange	2007–2008	Limit order book state, trades, buy/sell orders, order deletions	CNN	Accuracy, kappa	Caffe
[65]	Cryptocurrencies, Bitcoin	2014–2017	Price data	CNN, RNN, LSTM	Accumulative portfolio value, MDD, SR	–

Source: Ahmet Murat Ozbayoglu, Mehmet Ugur Gudelek, and Omer Berat Sezer (2020). "Deep learning for financial applications: A survey." Applied Soft Computing (2020): 106384.



# Deep learning for financial applications:

## Stand-alone and/or other algorithmic models

Art.	Data set	Period	Feature set	Method	Performance criteria	Environment
[66]	DAX, FTSE100, call/put options	1991–1998	Price data	Markov model, RNN	Ewa-measure, iv, daily profits' mean and std	–
[67]	Taiwan Stock Index Futures, Mini Index Futures	2012–2014	Price data to image	Visualization method + CNN	Accumulated profits, accuracy	–
[68]	Energy-Sector/ Company-Centric Tweets in S&P500	2015–2016	Text and Price data	LSTM, RNN, GRU	Return, SR, precision, recall, accuracy	Python, Tweepy API
[69]	CME FIX message	2016	Limit order book, time-stamp, price data	RNN	Precision, recall, F1-measure	Python, TensorFlow, R
[70]	Taiwan stock index futures (TAIFEX)	2017	Price data	Agent based RL with CNN pre-trained	Accuracy	–
[71]	Stocks from S&P500	2010–2016	OCHLV	DCNL	PCC, DTW, VWL	Pytorch
[72]	News from NowNews, AppleDaily, LTN, MoneyDJ for 18 stocks	2013–2014	Text, Sentiment	DMLP	Return	Python, Tensorflow
[73]	489 stocks from S&P500 and NASDAQ-100	2014–2015	Limit Order Book	Spatial neural network	Cross entropy error	NVIDIA's cuDNN
[74]	Experimental dataset	–	Price data	DRL with CNN, LSTM, GRU, DMLP	Mean profit	Python

# Deep learning for financial applications:

## Credit scoring or classification studies

Art.	Data set	Period	Feature set	Method	Performance criteria	Env.
[77]	The XR 14 CDS contracts	2016	Recovery rate, spreads, sector and region	DBN+RBM	AUROC, FN, FP, Accuracy	WEKA
[78]	German, Japanese credit datasets	–	Personal financial variables	SVM + DBN	Weighted-accuracy, TP, TN	–
[79]	Credit data from Kaggle	–	Personal financial variables	DMLP	Accuracy, TP, TN, G-mean	–
[80]	Australian, German credit data	–	Personal financial variables	GP + AE as Boosted DMLP	FP	Python, Scikit-learn
[81]	German, Australian credit dataset	–	Personal financial variables	DCNN, DMLP	Accuracy, False/Missed alarm	–
[82]	Consumer credit data from Chinese finance company	–	Relief algorithm chose the 50 most important features	CNN + Relief	AUROC, K-s statistic, Accuracy	Keras
[83]	Credit approval dataset by UCI Machine Learning repo	–	UCI credit approval dataset	Rectifier, Tanh, Maxout DL	–	AWS EC2, H2O, R

# Deep learning for financial applications:

## Financial distress, bankruptcy, bank risk, mortgage risk, crisis forecasting studies.

Art.	Data set	Period	Feature set	Method	Performance criteria	Env.
[84]	966 french firms	–	Financial ratios	RBM+SVM	Precision, Recall	–
[85]	883 BHC from EDGAR	2006–2017	Tokens, weighted sentiment polarity, leverage and ROA	CNN, LSTM, SVM, RF	Accuracy, Precision, Recall, F1-score	Keras, Python, Scikit-learn
[86]	The event data set for large European banks, news articles from Reuters	2007–2014	Word, sentence	DMLP +NLP preprocess	Relative usefulness, F1-score	–
[87]	Event dataset on European banks, news from Reuters	2007–2014	Text, sentence	Sentence vector + DFFN	Usefulness, F1-score, AUROC	–
[88]	News from Reuters, fundamental data	2007–2014	Financial ratios and news text	doc2vec + NN	Relative usefulness	Doc2vec
[89]	Macro/Micro economic variables, Bank characteristics/performance variables from BHC	1976–2017	Macro economic variables and bank performances	CGAN, MVN, MV-t, LSTM, VAR, FE-QAR	RMSE, Log likelihood, Loan loss rate	–
[90]	Financial statements of French companies	2002–2006	Financial ratios	DBN	Recall, Precision, F1-score, FP, FN	–
[91]	Stock returns of American publicly-traded companies from CRSP	2001–2011	Price data	DBN	Accuracy	Python, Theano
[92]	Financial statements of several companies from Japanese stock market	2002–2016	Financial ratios	CNN	F1-score, AUROC	–
[93]	Mortgage dataset with local and national economic factors	1995–2014	Mortgage related features	DMLP	Negative average log-likelihood	AWS
[94]	Mortgage data from Norwegian financial service group, DNB	2012–2016	Personal financial variables	CNN	Accuracy, Sensitivity, Specificity, AUROC	–
[95]	Private brokerage company's real data of risky transactions	–	250 features: order details, etc.	CNN, LSTM	F1-Score	Keras, Tensorflow
[96]	Several datasets combined to create a new one	1996–2017	Index data, 10-year Bond yield, exchange rates,	Logit, CART, RF, SVM, NN, XGBoost, DMLP	AUROC, KS, G-mean, likelihood ratio, DP, BA, WBA	R

# Deep learning for financial applications:

## Fraud detection studies

Art.	Data set	Period	Feature set	Method	Performance criteria	Env.
[114]	Debit card transactions by a local Indonesia bank	2016–2017	Financial transaction amount on several time periods	CNN, Stacked-LSTM, CNN-LSTM	AUROC	–
[115]	Credit card transactions from retail banking	2017	Transaction variables and several derived features	LSTM, GRU	Accuracy	Keras
[116]	Card purchases' transactions	2014–2015	Probability of fraud per currency/origin country, other fraud related features	DMLP	AUROC	–
[117]	Transactions made with credit cards by European cardholders	2013	Personal financial variables to PCA	DMLP, RF	Recall, Precision, Accuracy	–
[118]	Credit-card transactions	2015	Transaction and bank features	LSTM	AUROC	Keras, Scikit-learn
[119]	Databases of foreign trade of the Secretariat of Federal Revenue of Brazil	2014	8 Features: Foreign Trade, Tax, Transactions, Employees, Invoices, etc	AE	MSE	H2O, R
[120]	Chamber of Deputies open data, Companies data from Secretariat of Federal Revenue of Brazil	2009–2017	21 features: Brazilian State expense, party name, Type of expense, etc.	Deep Autoencoders	MSE, RMSE	H2O, R
[121]	Real-world data for automobile insurance company labeled as fraudulent	–	Car, insurance and accident related features	DMLP + LDA	TP, FP, Accuracy, Precision, F1-score	–
[122]	Transactions from a giant online payment platform	2006	Personal financial variables	GBDT+DMLP	AUROC	–
[123]	Financial transactions	–	Transaction data	LSTM	t-SNE	–
[124]	Empirical data from Greek firms	–	–	DQL	Revenue	Torch

Source: Ahmet Murat Ozbayoglu, Mehmet Ugur Gudelek, and Omer Berat Sezer (2020). "Deep learning for financial applications: A survey." Applied Soft Computing (2020): 106384.

# Deep learning for financial applications:

## Portfolio management studies

Art.	Data set	Period	Feature set	Method	Performance criteria	Env.
[65]	Cryptocurrencies, Bitcoin	2014–2017	Price data	CNN, RNN, LSTM	Accumulative portfolio value, MDD, SR	–
[127]	Stocks from NYSE, AMEX, NASDAQ	1965–2009	Price data	Autoencoder + RBM	Accuracy, confusion matrix	–
[128]	20 stocks from S&P500	2012–2015	Technical indicators	DMLP	Accuracy	Python, Scikit Learn, Keras, Theano
[129]	Chinese stock data	2012–2013	Technical, fundamental data	Logistic Regression, RF, DMLP	AUC, accuracy, precision, recall, f1, tpr, fpr	Keras, Tensorflow, Python, Scikit learn
[130]	Top 5 companies in S&P500	–	Price data and Financial ratios	LSTM, Auto-encoding, Smart indexing	CAGR	–
[131]	IBB biotechnology index, stocks	2012–2016	Price data	Auto-encoding, Calibrating, Validating, Verifying	Returns	–
[132]	Taiwans stock market	–	Price data	Elman RNN	MSE, return	–
[133]	FOREX (EUR/USD, etc.), Gold	2013	Price data	Evolino RNN	Return	Python
[134]	Stocks in NYSE, AMEX, NASDAQ, TAQ intraday trade	1993–2017	Price, 15 firm characteristics	LSTM+DMLP	Monthly return, SR	Python, Keras, Tensorflow in AWS
[135]	S&P500	1985–2006	monthly and daily log-returns	DBN+MLP	Validation, Test Error	Theano, Python, Matlab
[136]	10 stocks in S&P500	1997–2016	OCHLV, Price data	RNN, LSTM, GRU	Accuracy, Monthly return	Keras, Tensorflow
[137]	Analyst reports on the TSE and Osaka Exchange	2016–2018	Text	LSTM, CNN, Bi-LSTM	Accuracy, R <sup>2</sup>	R, Python, MeCab
[138]	Stocks from Chinese/American stock market	2015–2018	OCHLV, Fundamental data	DDPG, PPO	SR, MDD	–
[139]	Hedge fund monthly return data	1996–2015	Return, SR, STD, Skewness, Kurtosis, Omega ratio, Fund alpha	DMLP	Sharpe ratio, Annual return, Cum. return	–
[140]	12 most-volumed cryptocurrency	2015–2016	Price data	CNN + RL	SR, portfolio value, MDD	–

Source: Ahmet Murat Ozbayoglu, Mehmet Ugur Gudelek, and Omer Berat Sezer (2020). "Deep learning for financial applications: A survey." Applied Soft Computing (2020): 106384.

# Deep learning for financial applications:

## Asset pricing and derivatives market studies

Art.	Der. type	Data set	Period	Feature set	Method	Performance criteria	Env.
[137]	Asset pricing	Analyst reports on the TSE and Osaka Exchange	2016–2018	Text	LSTM, CNN, Bi-LSTM	Accuracy, $R^2$	R, Python, MeCab
[142]	Options	Simulated a range of call option prices	–	Price data, option strike/maturity, dividend/risk free rates, volatility	DMLP	RMSE, the average percentage pricing error	Tensorflow
[143]	Futures, Options	TAIEX Options	2017	OCHLV, fundamental analysis, option price	DMLP, DMLP with Black scholes	RMSE, MAE, MAPE	–
[144]	Equity returns	Returns in NYSE, AMEX, NASDAQ	1975–2017	57 firm characteristics	Fama–French n-factor model DL	$R^2$ , RMSE	Tensorflow

# Deep learning for financial applications:

## Cryptocurrency and blockchain studies

Art.	Data set	Period	Feature set	Method	Performance criteria	Env.
[46]	Bitcoin, Dash, Ripple, Monero, Litecoin, Dogecoin, Nxt, Namecoin	2014–2017	MA, BOLL, the CRIX daily returns, Euribor interest rates, OCHLV of EURO/UK, EURO/USD, US/JPY	LSTM, RNN, DMLP	Accuracy, F1-measure	Python, Tensorflow
[65]	Cryptocurrencies, Bitcoin	2014–2017	Price data	CNN	Accumulative portfolio value, MDD, SR	–
[140]	12 most-volumed cryptocurrency	2015–2016	Price data	CNN + RL	SR, portfolio value, MDD	
[145]	Bitcoin data	2010–2017	Hash value, bitcoin address, public/private key, digital signature, etc.	Takagi–Sugeno Fuzzy cognitive maps	Analytical hierarchy process	–
[146]	Bitcoin data	2012, 2013, 2016	TransactionId, input/output Addresses, timestamp	Graph embedding using heuristic, laplacian eigen-map, deep AE	F1-score	–
[147]	Bitcoin, Litecoin, StockTwits	2015–2018	OCHLV, technical indicators, sentiment analysis	CNN, LSTM, State Frequency Model	MSE	Keras, Tensorflow
[148]	Bitcoin	2013–2016	Price data	Bayesian optimized RNN, LSTM	Sensitivity, specificity, precision, accuracy, RMSE	Keras, Python, Hyperas

# Deep learning for financial applications:

## Financial sentiment studies coupled with text mining for forecasting

Art.	Data set	Period	Feature set	Method	Performance criteria	Env.
[137]	Analyst reports on the TSE and Osaka Exchange	2016–2018	Text	LSTM, CNN, Bi-LSTM	Accuracy, R <sup>2</sup>	R, Python, MeCab
[150]	Sina Weibo, Stock market records	2012–2015	Technical indicators, sentences	DRSE	F1-score, precision, recall, accuracy, AUROC	Python
[151]	News from Reuters and Bloomberg for S&P500 stocks	2006–2015	Financial news, price data	DeepClue	Accuracy	Dynet software
[152]	News from Reuters and Bloomberg, Historical stock security data	2006–2013	News, price data	DMLP	Accuracy	–
[153]	SCI prices	2008–2015	OCHL of change rate, price	Emotional Analysis + LSTM	MSE	–
[154]	SCI prices	2013–2016	Text data and Price data	LSTM	Accuracy, F1-Measure	Python, Keras
[155]	Stocks of Google, Microsoft and Apple	2016–2017	Twitter sentiment and stock prices	RNN	–	Spark, Flume, Twitter API,
[156]	30 DJIA stocks, S&P500, DJI, news from Reuters	2002–2016	Price data and features from news articles	LSTM, NN, CNN and word2vec	Accuracy	VADER
[157]	Stocks of CSI300 index, OCHLV of CSI300 index	2009–2014	Sentiment Posts, Price data	Naive Bayes + LSTM	Precision, Recall, F1-score, Accuracy	Python, Keras
[158]	S&P500, NYSE Composite, DJIA, NASDAQ Composite	2009–2011	Twitter moods, index data	DNN, CNN	Error rate	Keras, Theano



# Deep learning for financial applications:

## Text mining studies without sentiment analysis for forecasting

Art.	Data set	Period	Feature set	Method	Performance criteria	Env.
[68]	Energy-Sector/ Company-Centric Tweets in S&P500	2015–2016	Text and Price data	RNN, KNN, SVR, LinR	Return, SR, precision, recall, accuracy	Python, Tweepy API
[165]	News from Reuters, Bloomberg	2006–2013	Financial news, price data	Bi-GRU	Accuracy	Python, Keras
[166]	News from Sina.com, ACE2005 Chinese corpus	2012–2016	A set of news text	Their unique algorithm	Precision, Recall, F1-score	–
[167]	CDAX stock market data	2010–2013	Financial news, stock market data	LSTM	MSE, RMSE, MAE, Accuracy, AUC	TensorFlow, Theano, Python, Scikit-Learn
[168]	Apple, Airbus, Amazon news from Reuters, Bloomberg, S&P500 stock prices	2006–2013	Price data, news, technical indicators	TGRU, stock2vec	Accuracy, precision, AUROC	Keras, Python
[169]	S&P500 Index, 15 stocks in S&P500	2006–2013	News from Reuters and Bloomberg	CNN	Accuracy, MCC	–
[170]	S&P500 index news from Reuters	2006–2013	Financial news titles, Technical indicators	SI-RCNN (LSTM + CNN)	Accuracy	–
[171]	10 stocks in Nikkei 225 and news	2001–2008	Textual information and Stock prices	Paragraph Vector + LSTM	Profit	–
[172]	NIFTY50 Index, NIFTY Bank/Auto/IT/Energy Index, News	2013–2017	Index data, news	LSTM	MCC, Accuracy	–
[173]	Price data, index data, news, social media data	2015	Price data, news from articles and social media	Coupled matrix and tensor	Accuracy, MCC	Jieba
[174]	HS300	2015–2017	Social media news, price data	RNN-Boost with LDA	Accuracy, MAE, MAPE, RMSE	Python, Scikit-learn

Source: Ahmet Murat Ozbayoglu, Mehmet Ugur Gudelek, and Omer Berat Sezer (2020). "Deep learning for financial applications: A survey." Applied Soft Computing (2020): 106384.

# Deep learning for financial applications:

## Text mining studies without sentiment analysis for forecasting

Art.	Data set	Period	Feature set	Method	Performance criteria	Env.
[175]	News and Chinese stock data	2014–2017	Selected words in a news	HAN	Accuracy, Annual return	–
[176]	News, stock prices from Hong Kong Stock Exchange	2001	Price data and TF-IDF from news	ELM, DLR, PCA, BELM, KELM, NN	Accuracy	Matlab
[177]	TWSE index, 4 stocks in TWSE	2001–2017	Technical indicators, Price data, News	CNN + LSTM	RMSE, Profit	Keras, Python, TALIB
[178]	Stock of Tsugami Corporation	2013	Price data	LSTM	RMSE	Keras, Tensorflow
[179]	News, Nikkei Stock Average and 10-Nikkei companies	1999–2008	news, MACD	RNN, RBM+DBN	Accuracy, <i>P</i> -value	–
[180]	ISMIS 2017 Data Mining Competition dataset	–	Expert identifier, classes	LSTM + GRU + FFNN	Accuracy	–
[181]	Reuters, Bloomberg News, S&P500 price	2006–2013	News and sentences	LSTM	Accuracy	–
[182]	APPL from S&P500 and news from Reuters	2011–2017	Input news, OCHLV, Technical indicators	CNN + LSTM, CNN+SVM	Accuracy, F1-score	Tensorflow
[183]	Nikkei225, S&P500, news from Reuters and Bloomberg	2001–2013	Stock price data and news	DGM	Accuracy, MCC, %profit	–
[184]	Stocks from S&P500	2006–2013	Text (news) and Price data	LAR+News, RF+News	MAPE, RMSE	–

# Deep learning for financial applications:

## Financial sentiment studies coupled with text mining without forecasting

Art.	Data set	Period	Feature set	Method	Performance criteria	Env.
[85]	883 BHC from EDGAR	2006–2017	Tokens, weighted sentiment polarity, leverage and ROA	CNN, LSTM, SVM, Random Forest	Accuracy, Precision, Recall, F1-score	Keras, Python, Scikit-learn
[185]	SemEval-2017 dataset, financial text, news, stock market data	2017	Sentiments in Tweets, News headlines	Ensemble SVR, CNN, LSTM, GRU	Cosine similarity score, agreement score, class score	Python, Keras, Scikit Learn
[186]	Financial news from Reuters	2006–2015	Word vector, Lexical and Contextual input	Targeted dependency tree LSTM	Cumulative abnormal return	–
[187]	Stock sentiment analysis from StockTwits	2015	StockTwits messages	LSTM, Doc2Vec, CNN	Accuracy, precision, recall, f-measure, AUC	–
[188]	Sina Weibo, Stock market records	2012–2015	Technical indicators, sentences	DRSE	F1-score, precision, recall, accuracy, AUROC	Python
[189]	News from NowNews, AppleDaily, LTN, MoneyDJ for 18 stocks	2013–2014	Text, Sentiment	LSTM, CNN	Return	Python, Tensorflow
[190]	StockTwits	2008–2016	Sentences, StockTwits messages	CNN, LSTM, GRU	MCC, WSURT	Keras, Tensorflow
[191]	Financial statements of Japan companies	–	Sentences, text	DMLP	Precision, recall, f-score	–
[192]	Twitter posts, news headlines	–	Sentences, text	Deep-FASP	Accuracy, MSE, R <sup>2</sup>	–
[193]	Forums data	2004–2013	Sentences and keywords	Recursive neural tensor networks	Precision, recall, f-measure	–
[194]	News from Financial Times related US stocks	–	Sentiment of news headlines	SVR, Bidirectional LSTM	Cosine similarity	Python, Scikit Learn, Keras, Tensorflow

Source: Ahmet Murat Ozbayoglu, Mehmet Ugur Gudelek, and Omer Berat Sezer (2020). "Deep learning for financial applications: A survey." Applied Soft Computing (2020): 106384.

# Deep learning for financial applications:

## Other text mining studies

Art.	Data set	Period	Feature set	Method	Performance criteria	Env.
[72]	News from NowNews, AppleDaily, LTN, MoneyDJ for 18 stocks	2013–2014	Text, Sentiment	DMLP	Return	Python, Tensorflow
[86]	The event data set for large European banks, news articles from Reuters	2007–2014	Word, sentence	DMLP +NLP preprocess	Relative usefulness, F1-score	–
[87]	Event dataset on European banks, news from Reuters	2007–2014	Text, sentence	Sentence vector + DFFN	Usefulness, F1-score, AUROC	–
[88]	News from Reuters, fundamental data	2007–2014	Financial ratios and news text	doc2vec + NN	Relative usefulness	Doc2vec
[121]	Real-world data for automobile insurance company labeled as fraudulent	–	Car, insurance and accident related features	DMLP + LDA	TP, FP, Accuracy, Precision, F1-score	–
[123]	Financial transactions	–	Transaction data	LSTM	t-SNE	–
[195]	Taiwan's National Pension Insurance	2008–2014	Insured's id, area-code, gender, etc.	RNN	Accuracy, total error	Python
[196]	StockTwits	2015–2016	Sentences, StockTwits messages	Doc2vec, CNN	Accuracy, precision, recall, f-measure, AUC	Python, Tensorflow

# Deep learning for financial applications: Other theoretical or conceptual studies

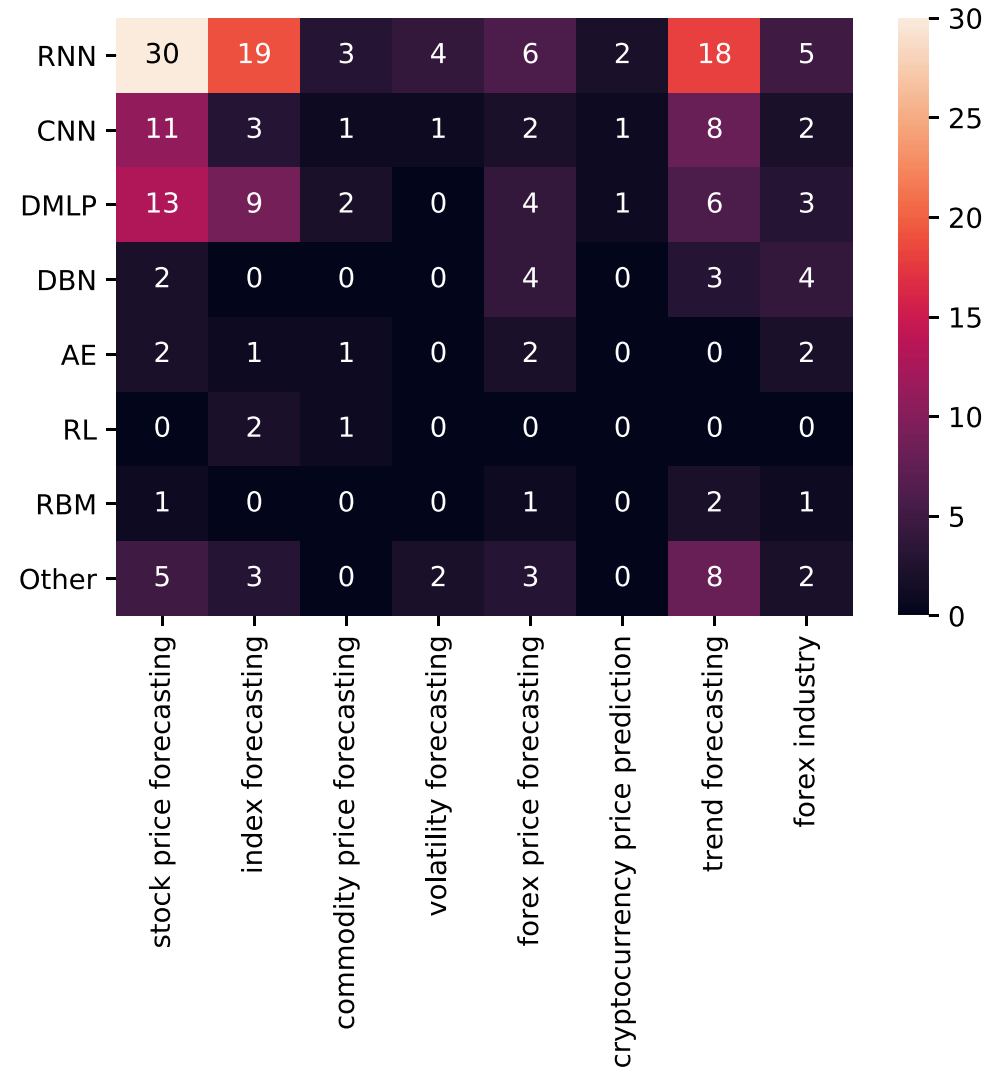
Art.	SubTopic	IsTimeSeries?	Data set	Period	Feature set	Method
[197]	Analysis of AE, SVD	Yes	Selected stocks from the IBB index and stock of Amgen Inc.	2012–2014	Price data	AE, SVD
[198]	Fraud Detection in Banking	No	Risk Management / Fraud Detection	–	–	DRL

# Deep learning for financial applications:

## Other financial applications

Art.	Subtopic	Data set	Period	Feature set	Method	Performance criteria	Env.
[47]	Improving trading decisions	S&P500, KOSPI, HSI, and EuroStoxx50	1987–2017	200-days stock price	Deep Q-Learning and DMLP	Total profit, Correlation	–
[193]	Identifying Top Sellers In Underground Economy	Forums data	2004–2013	Sentences and keywords	Recursive neural tensor networks	Precision, recall, f-measure	–
[195]	Predicting Social Ins. Payment Behavior	Taiwan's National Pension Insurance	2008–2014	Insured's id, area-code, gender, etc.	RNN	Accuracy, total error	Python
[199]	Speedup	45 CME listed commodity and FX futures	1991–2014	Price data	DNN	–	–
[200]	Forecasting Fundamentals	Stocks in NYSE, NASDAQ or AMEX exchanges	1970–2017	16 fundamental features from balance sheet	DMLP, LFM	MSE, Compound annual return, SR	–
[201]	Predicting Bank Telemarketing	Phone calls of bank marketing data	2008–2010	16 finance-related attributes	CNN	Accuracy	–
[202]	Corporate Performance Prediction	22 pharmaceutical companies data in US stock market	2000–2015	11 financial and 4 patent indicator	RBM, DBN	RMSE, profit	–

# Financial time series forecasting with deep learning: Topic-model heatmap



# Stock price forecasting using only raw time series data

Art.	Data set	Period	Feature set	Lag	Horizon	Method	Performance criteria	Env.
[80]	38 stocks in KOSPI	2010–2014	Lagged stock returns	50 min	5 min	DNN	NMSE, RMSE, MAE, MI	–
[81]	China stock market, 3049 Stocks	1990–2015	OCHLV	30 d	3 d	LSTM	Accuracy	Theano, Keras
[82]	Daily returns of 'BRD' stock in Romanian Market	2001–2016	OCHLV	–	1 d	LSTM	RMSE, MAE	Python, Theano
[83]	297 listed companies of CSE	2012–2013	OCHLV	2 d	1 d	LSTM, SRNN, GRU	MAD, MAPE	Keras
[84]	5 stock in NSE	1997–2016	OCHLV, Price data, turnover and number of trades.	200 d	1..10 d	LSTM, RNN, CNN, MLP	MAPE	–
[85]	Stocks of Infosys, TCS and CIPLA from NSE	2014	Price data	–	–	RNN, LSTM and CNN	Accuracy	–
[86]	10 stocks in S&P500	1997–2016	OCHLV, Price data	36 m	1 m	RNN, LSTM, GRU	Accuracy, Monthly return	Keras, Tensorflow
[87]	Stocks data from S&P500	2011–2016	OCHLV	1 d	1 d	DBN	MSE, norm-RMSE, MAE	–
[88]	High-frequency transaction data of the CSI300 futures	2017	Price data	–	1 min	DNN, ELM, RBF	RMSE, MAPE, Accuracy	Matlab
[89]	Stocks in the S&P500	1990–2015	Price data	240 d	1 d	DNN, GBT, RF	Mean return, MDD, Calmar ratio	H2O
[90]	ACI Worldwide, Staples, and Seagate in NASDAQ	2006–2010	Daily closing prices	17 d	1 d	RNN, ANN	RMSE	–
[91]	Chinese Stocks	2007–2017	OCHLV	30 d	1..5 d	CNN + LSTM	Annualized Return, Mxm Retracement	Python
[92]	20 stocks in S&P500	2010–2015	Price data	–	–	AE + LSTM	Weekly Returns	–
[93]	S&P500	1985–2006	Monthly and daily log-returns	*	1 d	DBN+MLP	Validation, Test Error	Theano, Python, Matlab
[94]	12 stocks from SSE Composite Index	2000–2017	OCHLV	60 d	1..7 d	DWNN	MSE	Tensorflow
[95]	50 stocks from NYSE	2007–2016	Price data	–	1d, 3 d, 5 d	SFM	MSE	–

Source: Omer Berat Sezer, Mehmet Ugur Gudelek, and Ahmet Murat Ozbayoglu (2020), "Financial time series forecasting with deep learning: A systematic literature review: 2005–2019." Applied Soft Computing 90 (2020): 106181.

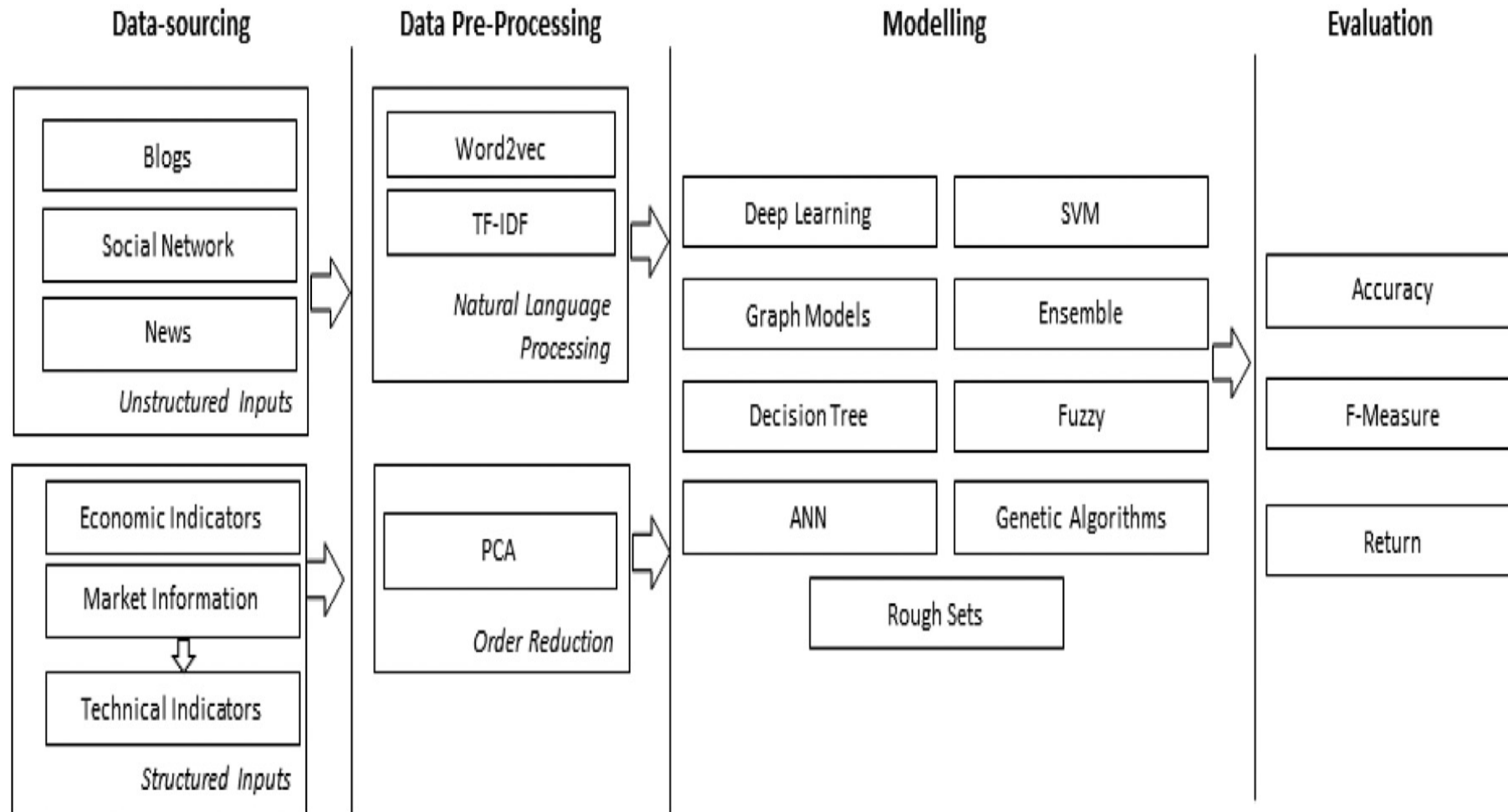


# Stock price forecasting using various data

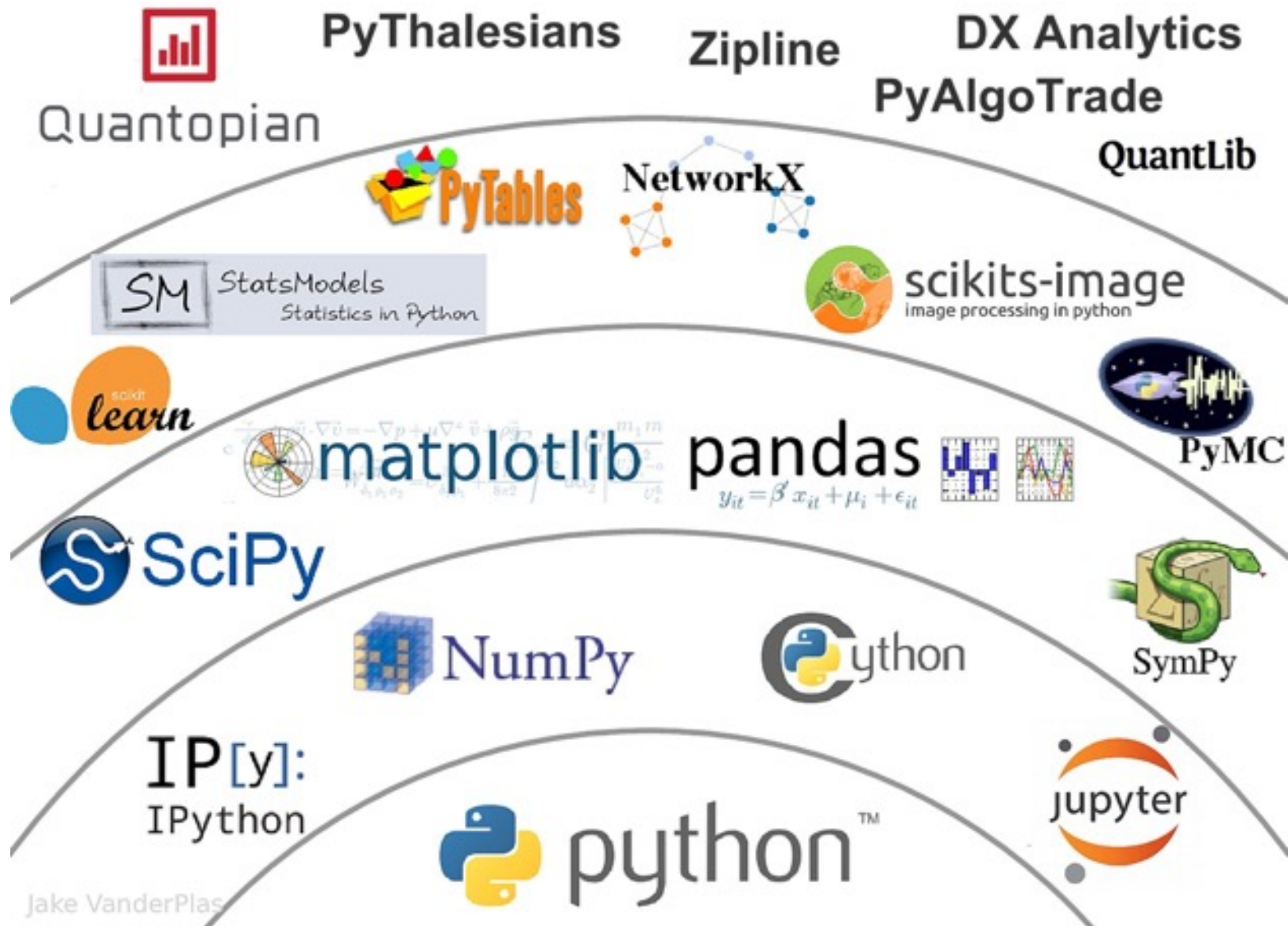
Art.	Data set	Period	Feature set	Lag	Horizon	Method	Performance criteria	Env.
[96]	Japan Index constituents from WorldScope	1990–2016	25 Fundamental Features	10 d	1 d	DNN	Correlation, Accuracy, MSE	Tensorflow
[97]	Return of S&P500	1926–2016	Fundamental Features:	–	1 s	DNN	MSPE	Tensorflow
[98]	U.S. low-level disaggregated macroeconomic time series	1959–2008	GDP, Unemployment rate, Inventories, etc.	–	–	DNN	R <sup>2</sup>	–
[99]	CDAX stock market data	2010–2013	Financial news, stock market data	20 d	1 d	LSTM	MSE, RMSE, MAE, Accuracy, AUC	TensorFlow, Theano, Python, Scikit-Learn
[100]	Stock of Tsugami Corporation	2013	Price data	–	–	LSTM	RMSE	Keras, Tensorflow
[101]	Stocks in China's A-share	2006–2007	11 technical indicators	–	1 d	LSTM	AR, IR, IC	–
[102]	SCI prices	2008–2015	OCHL of change rate, price	7 d	–	EmotionalAnalysis + LSTM	MSE	–
[103]	10 stocks in Nikkei 225 and news	2001–2008	Textual information and Stock prices	10 d	–	Paragraph Vector + LSTM	Profit	–
[104]	TKC stock in NYSE and QQQQ ETF	1999–2006	Technical indicators, Price	50 d	1 d	RNN (Jordan–Elman)	Profit, MSE	Java
[105]	10 Stocks in NYSE	–	Price data, Technical indicators	20 min	1 min	LSTM, MLP	RMSE	–
[106]	42 stocks in China's SSE	2016	OCHLV, Technical Indicators	242 min	1 min	GAN (LSTM, CNN)	RMSRE, DPA, GAN-F, GAN-D	–
[107]	Google's daily stock data	2004–2015	OCHLV, Technical indicators	20 d	1 d	(2D) <sup>2</sup> PCA + DNN	SMAPE, PCD, MAPE, RMSE, HR, TR, R <sup>2</sup>	R, Matlab
[108]	GarantiBank in BIST, Turkey	2016	OCHLV, Volatility, etc.	–	–	PLR, Graves LSTM	MSE, RMSE, MAE, RSE, R <sup>2</sup>	Spark
[109]	Stocks in NYSE, AMEX, NASDAQ, TAQ intraday trade	1993–2017	Price, 15 firm characteristics	80 d	1 d	LSTM+MLP	Monthly return, SR	Python,Keras, Tensorflow in AWS
[110]	Private brokerage company's real data of risky transactions	–	250 features: order details, etc.	–	–	CNN, LSTM	F1-Score	Keras, Tensorflow
[111]	Fundamental and Technical Data, Economic Data	–	Fundamental , technical and market information	–	–	CNN	–	–
[112]	The LOB of 5 stocks of Finnish Stock Market	2010	FI-2010 dataset: bid/ask and volume	–	*	WMTR, MDA	Accuracy, Precision, Recall, F1-Score	–
[113]	Returns in NYSE, AMEX, NASDAQ	1975–2017	57 firm characteristics	*	–	Fama–French n-factor model DL	R <sup>2</sup> , RMSE	Tensorflow

Source: Omer Berat Sezer, Mehmet Ugur Gudelek, and Ahmet Murat Ozbayoglu (2020), "Financial time series forecasting with deep learning: A systematic literature review: 2005–2019." Applied Soft Computing 90 (2020): 106181.

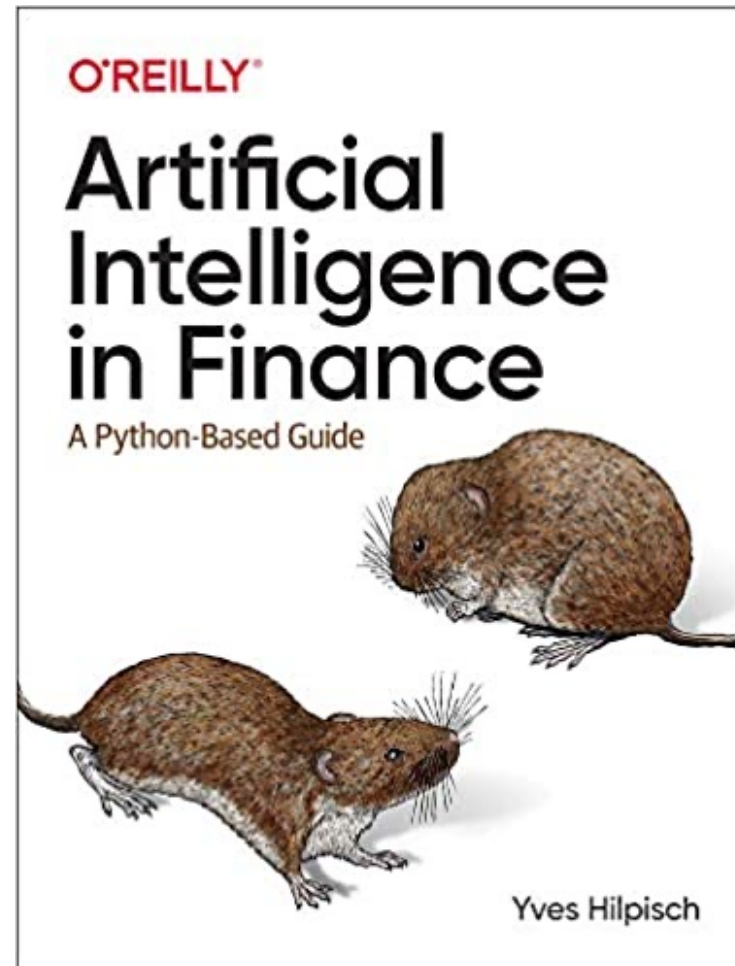
# Stock Market Movement Forecast: Phases of the stock market modeling



# The Quant Finance PyData Stack



Yves Hilpisch (2020),  
**Artificial Intelligence in Finance:**  
**A Python-Based Guide,**  
O'Reilly



# Yves Hilpisch (2020), **Artificial Intelligence in Finance: A Python-Based Guide**, O'Reilly

The screenshot shows the GitHub repository page for 'yhilpisch/aiif'. The repository is public and has 98 stars and 77 forks. The main branch is 'main'. The repository contains a folder named 'code' and files: '.gitignore', 'LICENSE.txt', and 'README.md'. The README.md file is open, showing the title 'Artificial Intelligence in Finance' and a description: 'This repository provides Python code and Jupyter Notebooks accompanying the Artificial Intelligence in Finance book published by O'Reilly.' The O'Reilly logo is visible at the bottom left of the README content. On the right side, there is an 'About' section with a link to 'home.tpq.io/books/aiif', a 'Releases' section with 'No releases published', a 'Packages' section with 'No packages published', and a 'Languages' section showing 'Jupyter Notebook 97.4%' and 'Python 2.6%'. A book cover for 'Artificial Intelligence in Finance: A Python-Based Guide' by Yves Hilpisch is shown on the right, featuring two mice on the cover.

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yves Code updates for TF 2.3. e334251 on Dec 8, 2020 4 commits

code	Code updates for TF 2.3.	11 months ago
.gitignore	Code updates for TF 2.3.	11 months ago
LICENSE.txt	Code updates.	11 months ago
README.md	Code updates.	11 months ago

README.md

## Artificial Intelligence in Finance

### About this Repository

This repository provides Python code and Jupyter Notebooks accompanying the **Artificial Intelligence in Finance** book published by [O'Reilly](#).

**O'REILLY**

**About**

Jupyter Notebooks and code for the book **Artificial Intelligence in Finance** (O'Reilly) by Yves Hilpisch.

[home.tpq.io/books/aiif](https://home.tpq.io/books/aiif)

Readme View license

**Releases**

No releases published

**Packages**

No packages published

**Languages**

Jupyter Notebook 97.4% Python 2.6%

**O'REILLY**

**Artificial Intelligence in Finance**  
A Python-Based Guide  
Yves Hilpisch

# Yves Hilpisch (2020), **Artificial Intelligence in Finance: A Python-Based Guide**, O'Reilly

yhilpisch / aiif Public

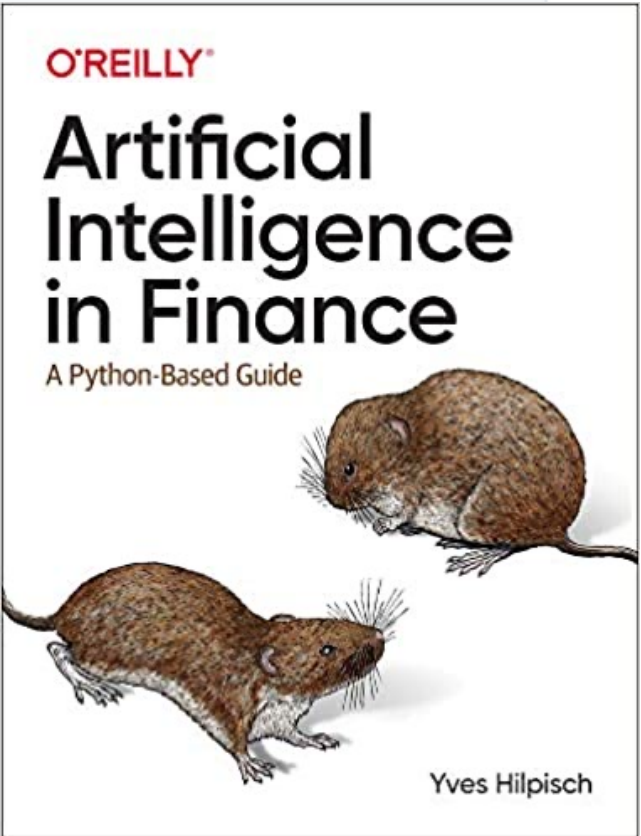
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main aiif / code / <https://github.com/yhilpisch/aiif/tree/main/code> Go to file

yves Code updates for TF 2.3. e334251 on Dec 8, 2020 History

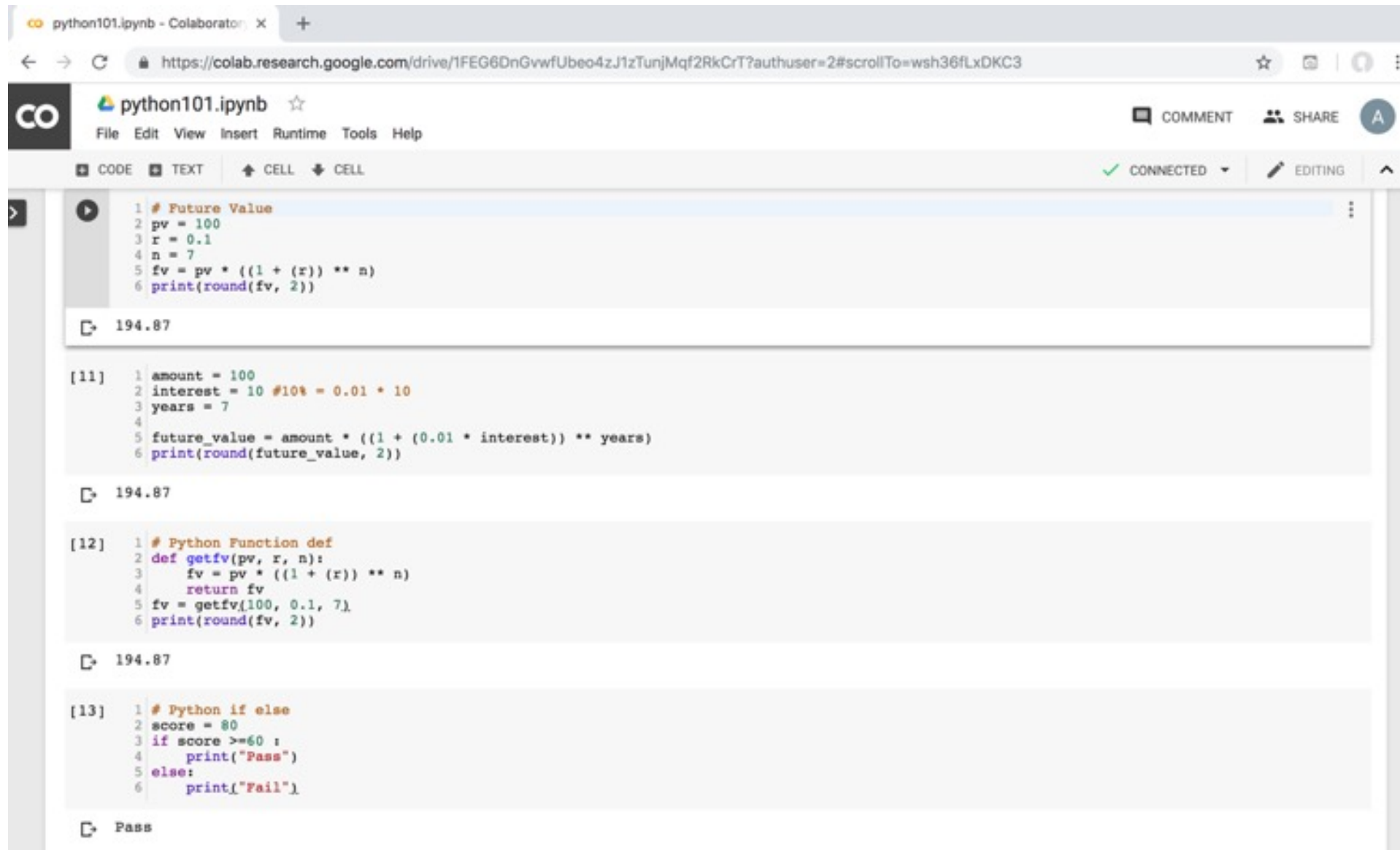
..	
oanda	Code updates for TF 2.3.
01_artificial_intelligence.ipynb	Code updates for TF 2.3.
02_superintelligence.ipynb	Code updates for TF 2.3.
03_normative_finance.ipynb	Code updates for TF 2.3.
04_data_driven_finance_a.ipynb	Initial commit.
04_data_driven_finance_b.ipynb	Initial commit.
05_machine_learning.ipynb	Code updates for TF 2.3.
06_ai_first_finance.ipynb	Code updates for TF 2.3.
07_dense_networks.ipynb	Code updates for TF 2.3.
08_recurrent_networks.ipynb	Code updates for TF 2.3.
09_reinforcement_learning_a.ipynb	Code updates.
09_reinforcement_learning_b.ipynb	Code updates for TF 2.3.



Source: <https://github.com/yhilpisch/aiif/tree/main/code>

# Python in Google Colab (Python101)

<https://colab.research.google.com/drive/1FEG6DnGvwfUbeo4zJ1zTunjMqf2RkCrT>



The screenshot shows a Google Colab notebook titled "python101.ipynb". The interface includes a browser address bar, a menu bar (File, Edit, View, Insert, Runtime, Tools, Help), and a toolbar with options like CODE, TEXT, CELL, and a status indicator showing "CONNECTED" and "EDITING".

The notebook contains four code cells:

- Cell 1:** A code cell with the following Python code:

```
1 # Future Value
2 pv = 100
3 r = 0.1
4 n = 7
5 fv = pv * ((1 + (r)) ** n)
6 print(round(fv, 2))
```

The output is "194.87".
- Cell 11:** A code cell with the following Python code:

```
1 amount = 100
2 interest = 10 #10% = 0.01 * 10
3 years = 7
4
5 future_value = amount * ((1 + (0.01 * interest)) ** years)
6 print(round(future_value, 2))
```

The output is "194.87".
- Cell 12:** A code cell with the following Python code:

```
1 # Python Function def
2 def getfv(pv, r, n):
3     fv = pv * ((1 + (r)) ** n)
4     return fv
5 fv = getfv(100, 0.1, 7)
6 print(round(fv, 2))
```

The output is "194.87".
- Cell 13:** A code cell with the following Python code:

```
1 # Python if else
2 score = 80
3 if score >=60 :
4     print("Pass")
5 else:
6     print("Fail")
```

The output is "Pass".

<https://tinyurl.com/aintpupython101>

# Python in Google Colab (Python101)

<https://colab.research.google.com/drive/1FEG6DnGvwfUbeo4zJ1zTunjMqf2RkCrT>

The screenshot displays a Google Colab notebook interface. At the top, the notebook title is 'python101.ipynb'. The navigation bar includes 'File', 'Edit', 'View', 'Insert', 'Runtime', 'Tools', and 'Help', along with 'All changes saved'. On the right, there are options for 'Comment', 'Share', and a user profile icon. Below the navigation bar, a 'Table of contents' sidebar is visible on the left, listing various topics such as 'AI in Finance', 'Normative Finance and Financial Theories', 'Uncertainty and Risk', 'Expected Utility Theory (EUT)', 'Mean-Variance Portfolio Theory (MVPT)', 'Capital Asset Pricing Model (CAPM)', 'Arbitrage Pricing Theory (APT)', 'Deep Learning for Financial Time Series Forecasting', 'Portfolio Optimization and Algorithmic Trading', 'Investment Portfolio Optimisation with Python', 'Efficient Frontier Portfolio Optimisation in Python', and 'Investment Portfolio Optimization'. The main content area shows a code cell with the following Python code:

```
1 import numpy as np
2
3 #The prices of the stock and bond today.
4 S0 = 10
5 B0 = 10
6 print('S0', S0)
7 print('B0', B0)
8
9 #The uncertain payoff of the stock and bond tomorrow.
10 S1 = np.array((20, 5))
11 B1 = np.array((11, 11))
12 print('S1', S1)
13 print('B1', B1)
14
15 #The market price vector
16 M0 = np.array((S0, B0))
```

<https://tinyurl.com/aintpupython101>



# Python in Google Colab (Python101)

The screenshot shows a Google Colab notebook interface. At the top, the notebook is titled 'python101.ipynb' and has a star icon. The menu bar includes 'File', 'Edit', 'View', 'Insert', 'Runtime', 'Tools', and 'Help', with a status 'All changes saved'. On the right, there are icons for 'Comment', 'Share', and a user profile 'A'. Below the menu, there are indicators for 'RAM' and 'Disk' usage, and a status 'Editing'.

The left sidebar contains a 'Table of contents' panel with a search icon and navigation arrows. The contents are as follows:

- Data Driven Finance
  - Financial Econometrics and Regression**
  - Data Availability
  - Normative Theories Revisited
    - Mean-Variance Portfolio Theory
    - Capital Asset Pricing Model
    - Arbitrage-Pricing Theory
  - Debunking Central Assumptions
  - Normality
    - Sample Data Sets
    - Real Financial Returns
  - Linear Relationships
- Deep Learning for Financial Time Series Forecasting
- Portfolio Optimization and Algorithmic Trading
  - Investment Portfolio Optimisation with Python
  - Efficient Frontier Portfolio Optimisation in Python
  - Investment Portfolio Optimization

The main content area shows three code cells:

```
[18] 1 import numpy as np
      2
      3 def f(x):
      4     return 2 + 1 / 2 * x
      5
      6 x = np.arange(-4, 5)
      7 x

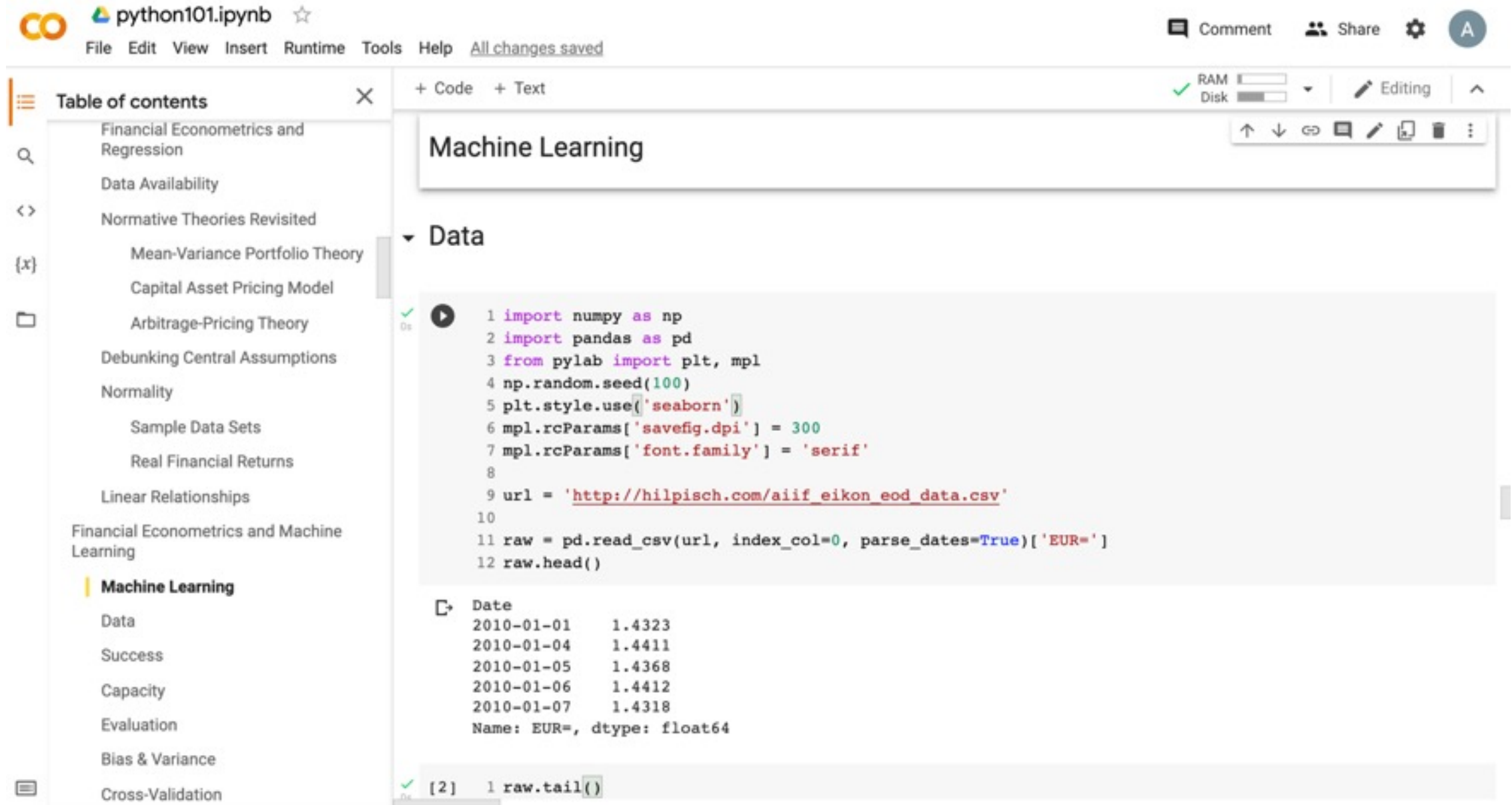
array([-4, -3, -2, -1,  0,  1,  2,  3,  4])
```

```
1 y = f(x)
2 y

array([ 0.00,  0.50,  1.00,  1.50,  2.00,  2.50,  3.00,  3.50,  4.00])
```

```
1 print('x', x)
2
3 print('y', y)
4
5 beta = np.cov(x, y, ddof=0)[0, 1] / x.var()
6 print('beta', beta)
```

# Python in Google Colab (Python101)



The screenshot shows a Google Colab notebook interface. At the top, the notebook is titled "python101.ipynb" and has a star icon. The menu bar includes "File", "Edit", "View", "Insert", "Runtime", "Tools", and "Help", with a status "All changes saved". On the right, there are icons for "Comment", "Share", and a user profile "A". Below the menu bar, there are RAM and Disk usage indicators, and a status "Editing".

The left sidebar contains a "Table of contents" with the following items:

- Financial Econometrics and Regression
- Data Availability
- Normative Theories Revisited
  - Mean-Variance Portfolio Theory
  - Capital Asset Pricing Model
- Arbitrage-Pricing Theory
- Debunking Central Assumptions
- Normality
  - Sample Data Sets
  - Real Financial Returns
- Linear Relationships
- Financial Econometrics and Machine Learning
  - Machine Learning**
  - Data
  - Success
  - Capacity
  - Evaluation
  - Bias & Variance
  - Cross-Validation

The main area shows a code cell with the following code:

```
1 import numpy as np
2 import pandas as pd
3 from pylab import plt, mpl
4 np.random.seed(100)
5 plt.style.use('seaborn')
6 mpl.rcParams['savefig.dpi'] = 300
7 mpl.rcParams['font.family'] = 'serif'
8
9 url = 'http://hilpisch.com/aiif_eikon_eod_data.csv'
10
11 raw = pd.read_csv(url, index_col=0, parse_dates=True)['EUR=']
12 raw.head()
```

The output of the code cell is a DataFrame:

```
Date
2010-01-01    1.4323
2010-01-04    1.4411
2010-01-05    1.4368
2010-01-06    1.4412
2010-01-07    1.4318
Name: EUR=, dtype: float64
```

Below the output, there is a code cell with the following code:

```
[2] 1 raw.tail()
```

# Python in Google Colab (Python101)

python101.ipynb ☆

File Edit View Insert Runtime Tools Help [All changes saved](#)

Comment Share Settings A

RAM  Disk  Editing ^

Table of contents

- Mean-Variance Portfolio Theory
- Capital Asset Pricing Model
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- Normality
- Sample Data Sets
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- Financial Econometrics and Machine Learning
- Machine Learning
- Data
- Success
- Capacity
- Evaluation
- Bias & Variance
- Cross-Validation
- AI-First Finance
  - Efficient Markets**
  - Market Prediction Based on Returns Data
  - Market Prediction With More Features
  - Market Prediction Intraday

+ Code + Text

## Efficient Markets

```
1 import numpy as np
2 import pandas as pd
3 from pylab import plt, mpl
4 plt.style.use('seaborn')
5 mpl.rcParams['savefig.dpi'] = 300
6 mpl.rcParams['font.family'] = 'serif'
7 pd.set_option('precision', 4)
8 np.set_printoptions(suppress=True, precision=4)
9
10 url = 'http://hilpisch.com/aiif_eikon_eod_data.csv'
11 data = pd.read_csv(url, index_col=0, parse_dates=True).dropna()
12 (data / data.iloc[0]).plot(figsize=(10, 6), cmap='coolwarm')
```

<matplotlib.axes.\_subplots.AxesSubplot at 0x7f29f972f210>

Asset	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
AAPL.O	1.0	1.2	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
MSFT.O	1.0	1.2	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
INTC.O	1.0	1.2	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
AMZN.O	1.0	1.2	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
GS.N	1.0	1.2	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
SPY	1.0	1.2	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
SPX	1.0	1.2	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
VIX	1.0	1.2	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
EUR=	1.0	1.2	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
XAU=	1.0	1.2	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
GDZ	1.0	1.2	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
GLD	1.0	1.2	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5

# Python in Google Colab (Python101)

python101.ipynb ☆

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Table of contents

- Deep Learning (DL) in Finance
  - Dense Neural Networks (DNN)
    - Baseline Prediction
    - Normalization
    - Dropout
    - Regularization
    - Bagging
    - Optimizers
  - Recurrent Neural Networks (RNN)
    - First Example
    - Second Example
    - Financial Price Series
    - Financial Return Series
    - Financial Features
    - Deep RNNs
  - Convolutional Neural Networks (CNN)
  - Reinforcement Learning (RL) in Finance

Deep Learning (DL) in Finance

- Source: Yves Hilpisch (2020), Artificial Intelligence in Finance: A Python-Based Guide, O'Reilly Media.
- Github: <https://github.com/yhilpisch/aiif/>

Dense Neural Networks (DNN)

```
1 import os
2 import numpy as np
3 import pandas as pd
4 from pylab import plt, mpl
5 plt.style.use('seaborn')
6 mpl.rcParams['savefig.dpi'] = 300
7 mpl.rcParams['font.family'] = 'serif'
8 pd.set_option('precision', 4)
9 np.set_printoptions(suppress=True, precision=4)
10 os.environ['PYTHONHASHSEED'] = '0'
```

```
[ ] 1 url = 'http://hilpisch.com/aiif_eikon_id_eur_usd.csv'
2 symbol = 'EUR_USD'
3 raw = pd.read_csv(url, index_col=0, parse_dates=True)
4 raw.head()
```

HIGH LOW OPEN CLOSE

# Python in Google Colab (Python101)

The screenshot shows a Google Colab notebook interface. At the top left is the Colab logo and the file name 'python101.ipynb'. The top right contains 'Comment', 'Share', and a user profile icon. Below the title bar is a menu with 'File', 'Edit', 'View', 'Insert', 'Runtime', 'Tools', and 'Help', along with the status 'All changes saved'. On the left is a 'Table of contents' sidebar with a search icon and a list of topics: 'Financial Features', 'Deep RNNs', 'Convolutional Neural Networks (CNN)', 'Reinforcement Learning (RL) in Finance' (highlighted), 'Reinforcement Learning (RL)', 'CartPole Environment', 'Dimensionality Reduction', 'Action Rule', 'Total Reward per Episode', 'Simple Learning', 'Testing the Results', 'DNN Learning', 'Q Learning', 'Finance Environment', 'Improved Finance Environment', and 'Improved Financial QL Agent'. The main area shows three sections: 1. 'Reinforcement Learning (RL) in Finance' with a list of sources: 'Source: Yves Hilpisch (2020), Artificial Intelligence in Finance: A Python-Based Guide, O'Reilly Media.' and 'Github: <https://github.com/yhilpisch/aiif/>'. 2. 'Reinforcement Learning (RL)' with a code cell containing: 

```
1 import os
2 import math
3 import random
4 import numpy as np
5 import pandas as pd
6 from pylab import plt, mpl
7 plt.style.use('seaborn')
8 mpl.rcParams['savefig.dpi'] = 300
9 mpl.rcParams['font.family'] = 'serif'
10 np.set_printoptions(precision=4, suppress=True)
11 os.environ['PYTHONHASHSEED'] = '0'
```

 3. 'CartPole Environment' with a code cell containing: 

```
[ ] 1 import gym
     2
```

# Python in Google Colab (Python101)

python101.ipynb ☆

File Edit View Insert Runtime Tools Help All changes saved

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Table of contents

- Algorithmic Trading
  - Vectorized Backtesting
  - Backtesting an SMA-Based Strategy
  - Backtesting a Daily DNN-Based Strategy
  - Backtesting an Intraday DNN-Based Strategy
- Risk Management
  - Trading Bot
  - Vectorized Backtesting
  - Event-Based Backtesting
  - Assessing Risk
  - Backtesting Risk Measures
    - Stop Loss
    - Trailing Stop Loss
    - Take Profit
    - Combinations
- Backtesting Cryptocurrency Bitcoin

+ Code + Text

Algorithmic Trading

- Source: Yves Hilpisch (2020), Artificial Intelligence in Finance: A Python-Based Guide, O'Reilly Media.
- Github: <https://github.com/yhilpisch/aiif/>

Vectorized Backtesting

```
1 import os
2 import math
3 import numpy as np
4 import pandas as pd
5 from pylab import plt, mpl
6 plt.style.use('seaborn')
7 mpl.rcParams['savefig.dpi'] = 300
8 mpl.rcParams['font.family'] = 'serif'
9 pd.set_option('mode.chained_assignment', None)
10 pd.set_option('display.float_format', '{:.4f}'.format)
11 np.set_printoptions(suppress=True, precision=4)
12 os.environ['PYTHONHASHSEED'] = '0'
```

Backtesting an SMA-Based Strategy

# Python in Google Colab (Python101)

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  - Assessing Risk
  - Backtesting Risk Measures
    - Stop Loss
    - Trailing Stop Loss
    - Take Profit
    - Combinations
- Backtesting Cryptocurrency
  - Bitcoin

The main code editor shows two code blocks:

```
1 import os
2 import math
3 import numpy as np
4 import pandas as pd
5 from pylab import plt, mpl
6 plt.style.use('seaborn')
7 mpl.rcParams['savefig.dpi'] = 300
8 mpl.rcParams['font.family'] = 'serif'
9 pd.set_option('mode.chained_assignment', None)
10 pd.set_option('display.float_format', '{:.4f}'.format)
11 np.set_printoptions(suppress=True, precision=4)
12 os.environ['PYTHONHASHSEED'] = '0'
```

```
[ ] 1 url = 'http://hilpisch.com/aiif_eikon_eod_data.csv'
2 symbol = 'EUR='
3 data = pd.DataFrame(pd.read_csv(url, index_col=0,
4                               parse_dates=True).dropna()[symbol])
5 data.info()
```

# Python in Google Colab (Python101)

CO python101.ipynb ☆

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Comment Share

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Table of contents

- Algorithmic Trading
  - Vectorized Backtesting**
    - Backtesting an SMA-Based Strategy
    - Backtesting a Daily DNN-Based Strategy
    - Backtesting an Intraday DNN-Based Strategy
  - Risk Management
    - Trading Bot
    - Vectorized Backtesting
    - Event-Based Backtesting
    - Assessing Risk
    - Backtesting Risk Measures
      - Stop Loss
      - Trailing Stop Loss
      - Take Profit
    - Combinations
  - Backtesting Cryptocurrency
    - Bitcoin

```
[ ] 1 data['r'] = np.log(data[symbol] / data[symbol].shift(1))
     2 data.dropna(inplace=True)
     3 data['s'] = data['p'] * data['r']
     4 data[['r', 's']].sum().apply(np.exp) # gross performance
     5 data[['r', 's']].sum().apply(np.exp) - 1 # net performance
     6 data[['r', 's']].cumsum().apply(np.exp).plot(figsize=(10, 6))
```

<matplotlib.axes.\_subplots.AxesSubplot at 0x7fd9f404fed0>

Year	r (Blue)	s (Green)
2011	1.00	1.00
2012	1.00	1.10
2013	1.00	1.10
2014	1.08	1.15
2015	1.00	1.25
2016	0.85	1.40
2017	0.85	1.35
2018	0.90	1.35
2019	0.88	1.35
2020	0.85	1.40



# Python in Google Colab (Python101)

python101.ipynb ☆

File Edit View Insert Runtime Tools Help All changes saved

Comment Share ⚙️ A

RAM  Disk  Editing ^

+ Code + Text

Table of contents

- Algorithmic Trading
  - Vectorized Backtesting
    - Backtesting an SMA-Based Strategy
    - Backtesting a Daily DNN-Based Strategy**
    - Backtesting an Intraday DNN-Based Strategy
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    - Trading Bot
    - Vectorized Backtesting
    - Event-Based Backtesting
    - Assessing Risk
    - Backtesting Risk Measures
      - Stop Loss
      - Trailing Stop Loss
      - Take Profit
      - Combinations
  - Backtesting Cryptocurrency
    - Bitcoin

```
1 test['s_'] = np.where(test['p'].diff() != 0,
2                       test['s'] - pc, test['s'])
3 # test['s_'].iloc[0] -= pc
4 test['s_'].iloc[-1] -= pc
5 test[['r', 's', 's_']].sum().apply(np.exp)
6 test[['r', 's', 's_']].sum().apply(np.exp) - 1
7 test[['r', 's', 's_']].cumsum().apply(np.exp).plot(figsize=(10, 6))
```

<matplotlib.axes.\_subplots.AxesSubplot at 0x7fd901d89910>

Date	r	s	s_
2018-01	1.00	1.00	1.00
2018-04	1.03	1.08	1.07
2018-07	0.98	1.15	1.14
2018-10	0.95	1.22	1.21
2019-01	0.94	1.30	1.29
2019-04	0.94	1.25	1.24
2019-07	0.93	1.28	1.27
2019-10	0.92	1.30	1.29
2020-01	0.93	1.28	1.27

# Python in Google Colab (Python101)

The screenshot shows a Google Colab notebook interface. At the top, the notebook is titled "python101.ipynb" and has a star icon. The top navigation bar includes "File", "Edit", "View", "Insert", "Runtime", "Tools", and "Help", with a status message "All changes saved". On the right side of the top bar, there are icons for "Comment", "Share", a settings gear, and a user profile icon labeled "A".

On the left side, there is a "Table of contents" sidebar with a search icon and a list of sections: "Algorithmic Trading", "Vectorized Backtesting", "Backtesting an SMA-Based Strategy", "Backtesting a Daily DNN-Based Strategy", "Backtesting an Intraday DNN-Based Strategy", "Risk Management" (highlighted with a yellow bar), "Trading Bot", "Vectorized Backtesting", "Event-Based Backtesting", "Assessing Risk", "Backtesting Risk Measures", "Stop Loss", "Trailing Stop Loss", "Take Profit", "Combinations", and "Backtesting Cryptocurrency Bitcoin".

The main area of the notebook contains two code cells. The first cell is titled "Risk Management" and contains the following Python code:

```
[ ] 1 import os
     2 import numpy as np
     3 import pandas as pd
     4 from pylab import plt, mpl
     5 plt.style.use('seaborn')
     6 mpl.rcParams['savefig.dpi'] = 300
     7 mpl.rcParams['font.family'] = 'serif'
     8 pd.set_option('mode.chained_assignment', None)
     9 pd.set_option('display.float_format', '{:.4f}'.format)
    10 np.set_printoptions(suppress=True, precision=4)
    11 os.environ['PYTHONHASHSEED'] = '0'
```

The second cell is titled "Trading Bot" and contains the following Python code:

```
[ ] 1 # import finance
     2 # finance.py
     3 # Finance Environment
     4 #
     5 # (c) Dr. Yves J. Hilpisch
     6 # Artificial Intelligence in Finance
     7 #
```

# Python in Google Colab (Python101)

The screenshot shows a Google Colab notebook interface. At the top, the notebook is titled 'python101.ipynb' and has a star icon. The menu bar includes 'File', 'Edit', 'View', 'Insert', 'Runtime', 'Tools', and 'Help', with a status 'All changes saved'. On the right, there are icons for 'Comment', 'Share', a settings gear, and a user profile 'A'. Below the menu, there are RAM and Disk usage indicators, and a toolbar with 'Editing' mode and various icons. A 'Table of contents' sidebar is on the left, listing various topics like 'Algorithmic Trading', 'Risk Management', and 'Event-Based Backtesting', which is currently selected. The main area shows a code cell with the following Python code:

```
1 #import backtesting as bt
2
3 # backtesting.py
4 # Event-Based Backtesting
5 # --Base Class (1)
6 #
7 # (c) Dr. Yves J. Hilpisch
8 # Artificial Intelligence in Finance
9 #
10
11 class BacktestingBase:
12     def __init__(self, env, model, amount, ptc, ftc, verbose=False):
13         self.env = env
14         self.model = model
15         self.initial_amount = amount
16         self.current_balance = amount
17         self.ptc = ptc
18         self.ftc = ftc
19         self.verbose = verbose
20         self.units = 0
21         self.trades = 0
22
23     def get_date_price(self, bar):
24         ''' Returns date and price for a given bar.
25         ...
```

# Python in Google Colab (Python101)

The screenshot shows a Google Colab notebook interface. At the top, the notebook title is 'python101.ipynb' with a star icon. Below the title is a menu bar with 'File', 'Edit', 'View', 'Insert', 'Runtime', 'Tools', and 'Help', followed by the text 'All changes saved'. On the right side of the top bar, there are icons for 'Comment', 'Share', a settings gear, and a user profile icon labeled 'A'. Below the top bar, there are resource indicators for 'RAM' and 'Disk' with progress bars, and a status 'Editing' with an up arrow icon.

On the left side, there is a 'Table of contents' sidebar with a search icon and a close button. The sidebar lists various sections: 'Algorithmic Trading', 'Vectorized Backtesting', 'Backtesting an SMA-Based Strategy', 'Backtesting a Daily DNN-Based Strategy', 'Backtesting an Intraday DNN-Based Strategy', 'Risk Management', 'Trading Bot', 'Vectorized Backtesting', 'Event-Based Backtesting', 'Assessing Risk', 'Backtesting Risk Measures', 'Stop Loss', 'Trailing Stop Loss', 'Take Profit', 'Combinations' (highlighted with a yellow bar), and 'Backtesting Cryptocurrency Bitcoin'.

The main content area shows a code cell with the following code:

```
1 tb.backtest_strategy(sl=0.015, tsl=None,  
2                       tp=0.0185, wait=5)
```

The output of the code cell is a series of text lines representing backtest results, separated by dashed lines:

```
=====
2018-01-17 | *** START BACKTEST ***
2018-01-17 | current balance = 10000.00
=====
*** STOP LOSS (SHORT | -0.0203) ***
=====
*** STOP LOSS (SHORT | -0.0152) ***
=====
*** TAKE PROFIT (SHORT | 0.0189) ***
=====
*** TAKE PROFIT (SHORT | 0.0219) ***
=====
*** TAKE PROFIT (SHORT | 0.0192) ***
=====
*** STOP LOSS (LONG | -0.0154) ***
=====
*** TAKE PROFIT (SHORT | 0.0214) ***
=====
*** STOP LOSS (SHORT | -0.0158) ***
=====
*** TAKE PROFIT (SHORT | 0.0223) ***
=====
*** STOP LOSS (SHORT | -0.0162) ***
=====
```

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The left sidebar contains a 'Table of contents' with the following items:

- Algorithmic Trading
  - Vectorized Backtesting
    - Backtesting an SMA-Based Strategy
    - Backtesting a Daily DNN-Based Strategy
    - Backtesting an Intraday DNN-Based Strategy
  - Risk Management
    - Trading Bot
    - Vectorized Backtesting
    - Event-Based Backtesting
    - Assessing Risk
    - Backtesting Risk Measures
      - Stop Loss
      - Trailing Stop Loss
      - Take Profit
      - Combinations
- Backtesting Cryptocurrency Bitcoin

The main content area shows a section titled 'Backtesting Cryptocurrency Bitcoin' with two bullet points:

- Financial Functions (ffn): <https://pmorrisette.github.io/ffn/>
- backtesting.py: <https://kernc.github.io/backtesting.py/>

Below this is a code cell with a play button icon and a '15s' timer. The code is as follows:

```
1 !pip install ffn
2 import ffn
3 import plotly.express as px
4 %pylab inline
5 #BTC-USD Bitcoin USD
6 df = ffn.get('btc-usd', start='2016-01-01', end='2021-12-31')
7 print('df')
8 print(df.head())
9 print(df.tail())
10 print(df.describe())
11 df.plot(figsize=(14,10))
12
13 returns = df.to_returns().dropna()
14 print('returns')
15 print(returns.head())
16 print(returns.tail())
17 print(returns.describe())
18 #ax = df.plot(figsize=(12,9))
19
20 perf = df.calc_stats()
21 perf.plot(figsize=(14, 10))
```

# Python in Google Colab (Python101)

CO python101.ipynb ☆

File Edit View Insert Runtime Tools Help All changes saved

Comment Share

RAM Disk Editing

Table of contents

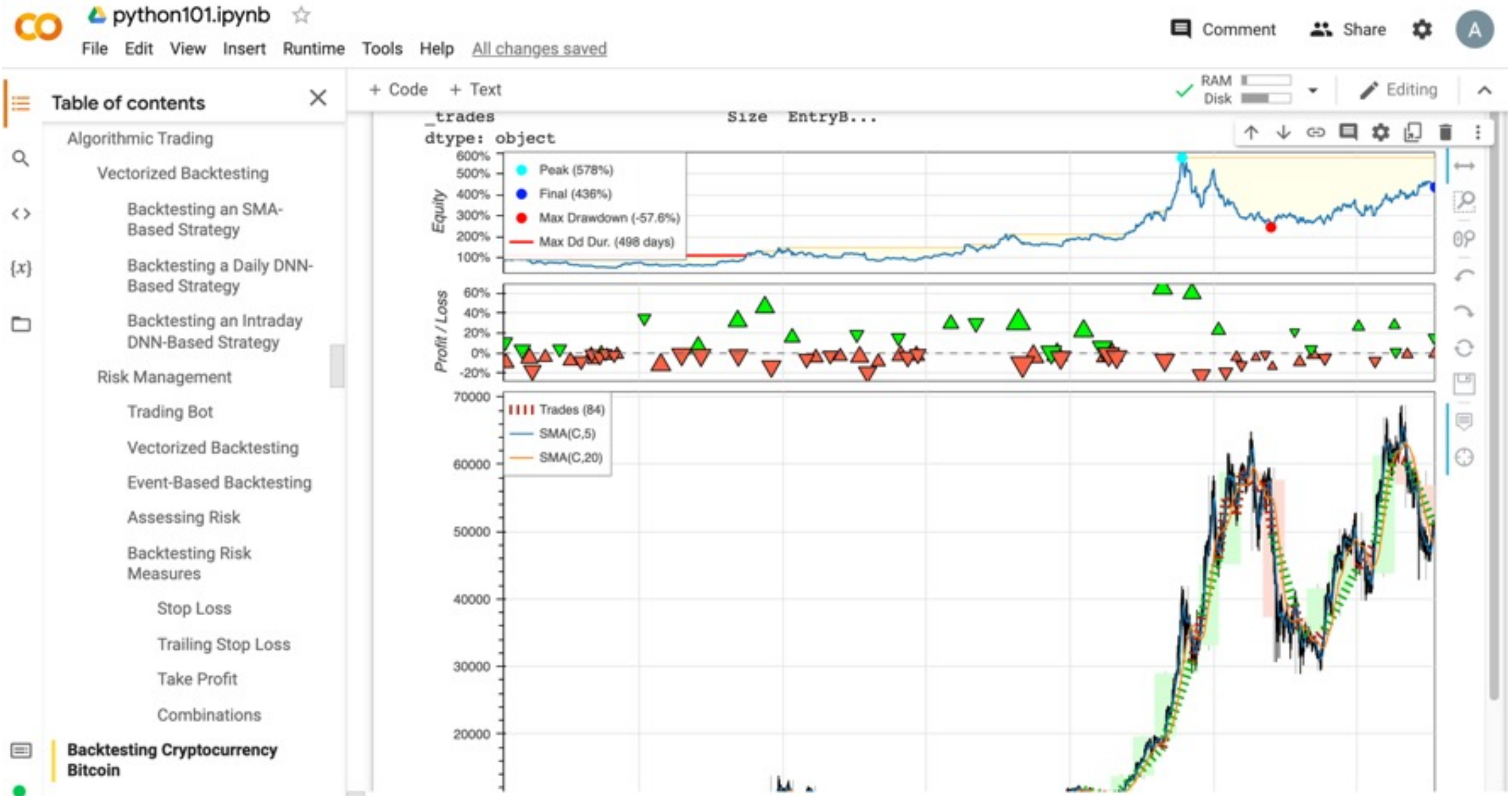
- Algorithmic Trading
  - Vectorized Backtesting
    - Backtesting an SMA-Based Strategy
    - Backtesting a Daily DNN-Based Strategy
    - Backtesting an Intraday DNN-Based Strategy
  - Risk Management
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- Backtesting Cryptocurrency
  - Bitcoin

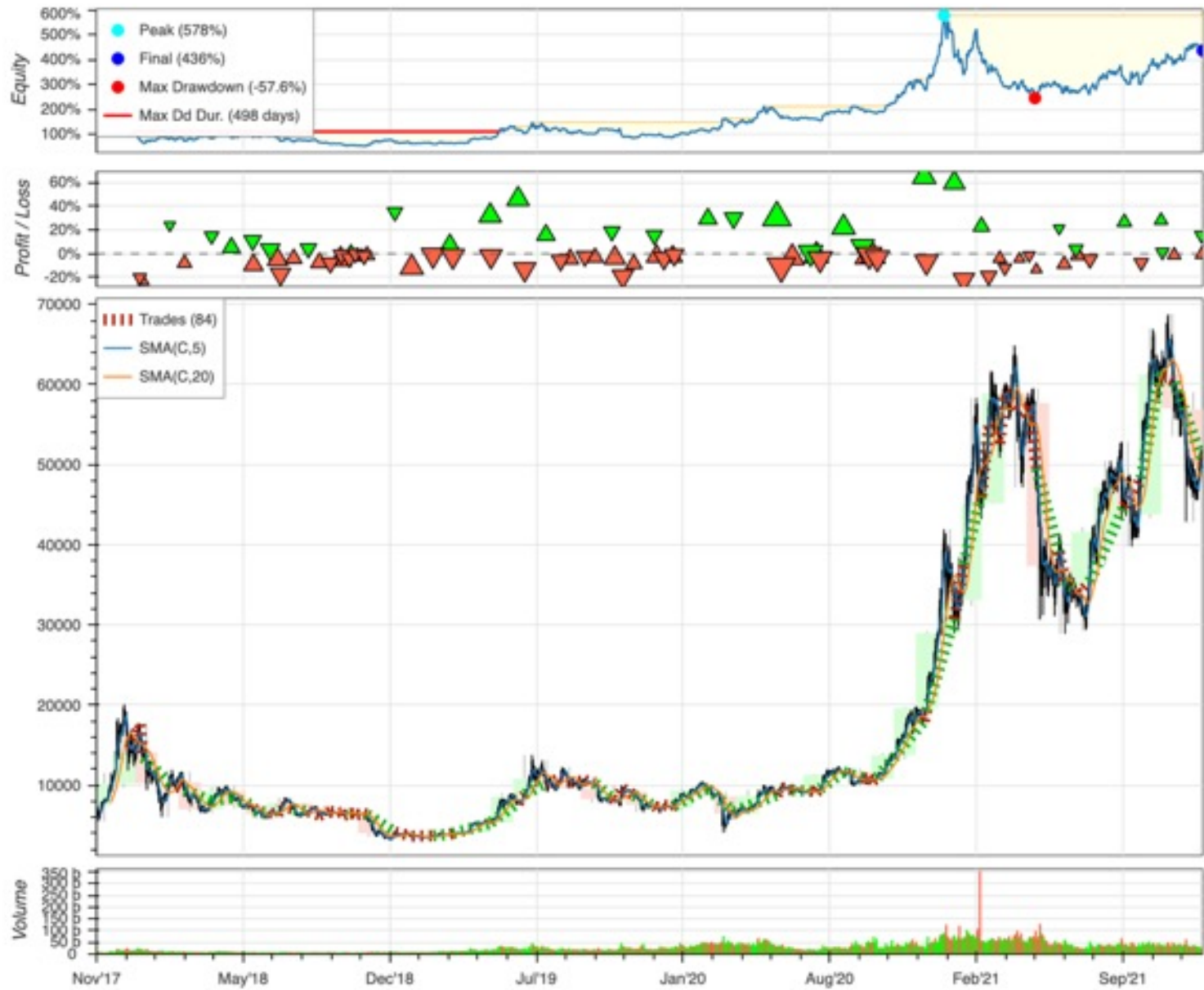
+ Code + Text

btcusd returns box

The figure is a box plot titled "btcusd returns box". The vertical axis is labeled "btcusd" and has tick marks at -0.4, -0.3, -0.2, -0.1, 0, 0.1, and 0.2. The plot shows a distribution of returns. The central box (interquartile range) is centered around 0, with the median line slightly above 0. Whiskers extend from approximately -0.08 to 0.08. There are several outliers, with the most prominent ones at approximately 0.25 and -0.35.

# Python in Google Colab (Python101)







# Teaching



- **Artificial Intelligence in Finance and Quantitative**
  - Fall 2021, Fall 2022
- **Artificial Intelligence**
  - Spring 2021, Fall 2022
- **Software Engineering**
  - Fall 2020, Fall, 2021, Spring 2022, Spring 2023
- **Artificial Intelligence for Text Analytics**
  - Spring 2022
- **Data Mining**
  - Spring 2021
- **Big Data Analytics**
  - Fall 2020
- **Foundation of Business Cloud Computing**
  - Spring 2021, Spring 2022, Spring 2023

# Research Project



- **Applying AI technology to construct knowledge graphs of cryptocurrency anti-money laundering: a few-shot learning model**
  - MOST, 110-2410-H-305-013-MY2, 2021/08/01~2023/07/31
- **AI for Corporate Sustainability Assessment and Cross Language Corporate Sustainability Reports Generative Mode**
  - NTPU, 111-NTPU\_ORDA-F-001 , 2022/01/01~2022/12/31
- **Artificial Intelligence for FinTech Knowledge Graph from Patent Textual Analytics**
  - NTPU, 111-NTPU\_ORDA-F-003, 2022/01/01~2022/12/31

# Summary

- This course introduces the **fundamental concepts, research issues, and hands-on practices of AI in Finance and Quantitative Analysis.**
- **Topics include:**
  1. Introduction to Artificial Intelligence in Finance and Quantitative Analysis
  2. AI in FinTech: Metaverse, Web3, DeFi, NFT, Financial Services Innovation and Applications,
  3. Investing Psychology and Behavioral Finance
  4. Event Studies in Finance
  5. Finance Theory
  6. Data-Driven Finance
  7. Financial Econometrics
  8. AI-First Finance
  9. Deep Learning in Finance
  10. Reinforcement Learning in Finance
  11. Algorithmic Trading, Risk Management, Trading Bot and Event-Based Backtesting
  12. Case Study on AI in Finance and Quantitative Analysis.



# AI in Finance and Quantitative Analysis



2020 Cohort



Accredited  
Educator



certified

Solutions  
Architect

Associate



certified

Cloud  
Practitioner

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